Geography is that branch of science that seeks to explain, predict, and otherwise analyze the location and magnitude of phenomena at or near the earth’s surface. These phenomena may be actual surface patterns (e.g., cities or river networks), or they may be phenomena that for a given time may be mapped (e.g., peak hour traffic in London during an average day in 2000, or migration flows between states of the United States between 1995 and 2000). Where sufficiently detailed information is available, the geographer can examine the processes that have led to the formation of a given spatial pattern.

Transportation is the movement of goods or people from one location to another location. Broadly defined, this includes just about every type of movement possible, so we need to limit the definition somewhat. Thus, transportation is the movement of goods beyond their local production area and the movement of people between different geographical locations. Such a definition enables us to disregard the movement of goods within a plant or within an industrial complex, of people within an establishment, and of the migration of populations, topics that are examined by other disciplines.

The transportation geographer’s interests center on both the location and geographic pattern of transport systems and the magnitude of the movement or spatial interaction over the elements of such systems.

Defining geography as that branch of science that seeks to explain, predict, and otherwise analyze the location and magnitude of phenomena at or near the earth’s surface does have implications for transportation. Implicit in this type of definition is the existence of some type of differentiation; that is, the surface of the earth differs from place to place. If this were not the case, there would be no variation. All places would be much the same and as a result there would be no need for transport and travel beyond local areas since there would be nothing in the rest of the world different from where we are at present. Everyone and every place would have the same resources and capabilities.

However, the surface of the earth is different from place to place. Places differ in
terms of population size, language, resources, environmental factors, industrial specialization, local history, and human activities. It is these differences from place to place that generate the demand for transportation. People want commodities that are not produced locally—for example, fruits, vegetables, televisions, shoes, paper, and thousands of other goods—and this desire generates demand for transport. Businesses need resources that are often not available locally, and this need generates a demand for transportation. We vacation in areas that have different histories (battlefields, medieval castles, colonial origins), different environments (coastal areas, the mountains, wilderness areas, the tropics) and different attractions (largest structures, major amusement parks, casinos, etc.). We work, shop, worship, and seek entertainment, for the most part, outside our own neighborhoods, necessitating a journey to work, to shop, to go to church, to visit the multiplex or video store. Transport enables us to carry out all these activities. One can see how geography influences transport and transport enables us to cope with geography.

Transport has other ties to the study of geography. A major portion of the field of geography has as its focus human interactions with the environment. Transport is one of the major ways in which humans impact their environment. The atmospheric impacts are among the best known of these; they include air pollution, greenhouse gas emissions, acid deposition, and ozone layer destruction. However, there are many other ways in which transport impacts the environment. It is capable of altering soils, geomorphology, waters, and plant and animal life. Although these impacts are primarily negative, it goes without saying that transport brings many good things to our lives as well.

Many years ago transport geographer Edward L. Ullman (1954a) published a paper entitled “Geography as Spatial Interaction.” Ullman saw the field of transport geography as the definitive center of the field of geography. He believed that it was the manner in which humans interact with their world—their spatial interaction—that defined the field. Some might not go so far today, but Ullman’s views are illustrative of the importance of this field to the overall discipline of geography.

Geographers do not have a monopoly on the spatial approach or the examination of spatial relationships. Engineers and other social scientists contributed to the development of the more scientific aspects of the field recognized here as transport geography. One of the earliest contributions focusing on the importance of transport and transport costs is an 1826 work by J. H. von Thunen (1875), Der Isolierte Staat. In this study the author clearly shows the manner in which distance and transport costs affect land rents. Dunn (1955) made many of these ideas available to geographers.

Another early contribution to this field came from the work of Leon Lalanne (1863), a French civil engineer. His paper sought to point out certain fundamental relationships between the distribution of places, their sizes, and the number of transport routes serving them. These ideas were to be advanced further during the 20th century with the work of the geographer Walter Christaller (1933). Another engineer who made a fundamental contribution to our understanding of transport network development was A. M. Wellington (1887). Wellington’s concern was, which places should be connected to a railroad route that was to pass between two known end points. He recognized a financial desire to pick up additional traffic, if any was to be had, but not if deviations from a least cost route were excessive.

Of course, one should not overlook the work of historians in advancing our understanding of transport development. In order to understand the development of transport
routes and networks, one must take a historical approach. Much of what we know today about transport route location is the result of research by historians and historical geographers; moreover, many of the academic mistakes made in modeling are attributable to ignoring the work of these scholars. The works of Ringwalt (1888) and Dunbar (1915) are critical to understanding transport development in the United States. Vance (1986) prepared a more recent treatment of transport development in the United States and Europe. In the case of British road transport, one should be aware of the works of Anderson (1932) and Parnell (1838). Construction of the National Road in the United States used the ideas and plans of Thomas Telford, an engineer who designed many of the roads in England during the first and second decade of the 1800s, which were available (Gibb, 1935). Of course, a thorough understanding of world transport history, even for a single mode, would consume an entire career, but an awareness of at least some of this literature is advisable for any transport researcher.

Systematic treatments of what could be called transport geography are difficult to come by prior to the middle of the 20th century. Among the few notable pieces is Mark Jefferson’s (1928) “The Civilizing Rails,” a cartographic study of world railroad development. One can only imagine the time and effort it took for Jefferson to prepare the maps of that study in comparison to the use of geographic information systems (GIS) and transport databases today that could prepare the same in only minutes (or less). Pearcy and Alexander’s (1951, 1953) work on airline development is also notable for its completeness on a subject that was still evolving at the time their work was completed.

Ullman’s (1957) *American Commodity Flow* represents the first systematic attempt to explain what was happening with commodity movement in the United States. It is proper to view it as the beginning of scientific treatment of the subject in the United States.

Ullman, with Harold Mayer (1954b), surveyed the field of transportation geography in their volume *American Geography: Inventory and Prospect*. Their paper on transportation geography examined the field and identified 11 areas of interest to transport geographers at the time. These were:

1. Examination and mapping of transportation as a measure of relations between areas.
2. The study of ports, their traffic, and hinterlands.
3. Comparisons of transportation systems and the identification of criteria for such comparisons.
4. The patterns and selection of transportation routes.
5. The problem of securing adequate data on flows.
7. Examination of existing or given traffic flows and evaluation of their efficiency.
8. Analysis of the components of freight rates.
9. Studies of the relationship between transport routes and environmental conditions.
10. Studies of the impact of technology on transport costs and flows.
11. The gravity model and social physics.

This volume examines most of these topics. It does not examine port cities with their facilities, traffic, and hinterlands as such, since these seem to be more of interest to urban
geographers today. It will, however, examine ports as nodes of a network that both produce and attract flows from other areas.

THE NETWORK APPROACH

Most of the other areas of interest in the 1954 Ullman and Mayer survey continue to be of concern today, although major changes in both transportation research and geographical research have altered them since that time. Geography underwent some major methodological and philosophical changes during the 1950s. Transportation geography proved to be a focus of much of this change. Exactly when the effects of this change were felt in transportation geography is difficult to determine, but, based on the literature, it occurred between 1956 and 1960. The prime innovators of change were E. L. Ullman, W. L. Garrison and W. Bunge, all of whom were colleagues at the University of Washington at the time.

Ullman’s primary contributions were his review of the field (1954b) and his monograph on American Commodity Flow (1957). Although a review is rarely recognized as a contribution, this one was in that it pointed out several areas where research was needed. In his subsequent monograph Ullman succinctly specified the three basic determinants of trade and spatial interaction: complementarity, intervening opportunities, and transferability—all of which are discussed later in this book. In addition, Ullman was one of the first geographers to suggest that the gravity model should be applicable to the analysis of flows between regions.

Bunge’s (1966) Theoretical Geography with its emphasis on spatial variables and location helped to fill a partial void in transportation geography research created by a paucity of studies concerned with the location of transport routes and networks. A possible explanation for this lack of development was that locations of these facilities were examined only if they affected the pattern of circulation (movement). Bunge suggested that the location patterns of the facilities were worth examining in and of themselves, and he ventured outside the geographical literature in his search for theory relevant to the locations of these facilities as well as for theory that would increase our understanding of movement and spatial interaction.

Garrison’s influence on transportation geography began in the late 1950s with the publication of three review papers on the spatial structure of the economy (Garrison, 1959a, 1959b, 1960a). The first two papers concerned location theory and transportation costs as a determinant of the optimal location of production. The third paper in the series noted the importance of the direct study of transportation networks as a research area rather than as an explanatory variable in the study of spatial interaction. At about the same time, Garrison, often working alone and often with Ullman and Brian Berry, tested the gravity model in an attempt to verify the concepts of interaction (Garrison, 1956b), and made research contributions in the area of network impact and network enlargement that are regarded as classics today (Garrison & Berry, 1957; Garrison & Marble, 1958; Garrison, Berry, Marble, Nystuen, & Morrill, 1959).

The association of Garrison and Marble (1965) also resulted in the Prolegomenon to the Forecasting of Transportation Development. This research report and the preliminary papers from which it was formed had a significant impact on the scope and methods utilized in transportation geography for more than two decades, and, it continues to be a
frequently cited source in any discussion of the network approach to transport geography. Of equal importance at the time was Haggett’s (1966) *Locational Analysis in Human Geography*, which was followed a couple years later by Haggett and Chorley’s (1969) *Network Analysis in Geography*. These were major textbooks that promoted and spread new methods into all areas of the discipline that were known only to a small group of scholars before this time. An excellent summary of the network literature will be found in Leinbach (1976).

**EXTERNAL INFLUENCES ON THE FIELD**

In addition to the work of the individuals discussed so far, several external factors influenced the direction that transportation geography research in the last half of the 20th century would take. There were three major stimuli. One of the most significant was the post-World War II recognition by city planners, governments, and so on of the transportation problems facing urban areas. Initially, geographers avoided these problems primarily because the field was very descriptive at the time and had not developed ways to analyze them. But they couldn’t avoid them forever, because the problems were inherently geographical in nature. The problems had to do with areal variation in traffic produced in subareas of a city (trip generation); the examination and prediction of flows between subareas (trip distribution or spatial interaction); and the identification of minimum distance or time paths for these flows over a network (trip assignment). Perhaps no other subfield of geography has problems that are so inherently geographical.

A second external influence was the development of research technologies capable of handling the complex problems encountered in transportation research. High-speed computer hardware and the development of linear programming are prime examples of these technological changes. The field of operations research, which is itself a product of these innovations, served as a stimulus to both Garrison and Bunge in their previously noted works.

A third stimulus to occur at this time was an apparent decrease in the importance of transportation economics as a subfield of economics. In addition, economists throughout the United States and elsewhere ignored transportation and its costs when discussing the theory of the firm. Isard (1956) referred to this as the “anglo-saxon bias.” The few transport economics programs that did exist were being absorbed by courses in public utility economics or logistics. Prior to this absorption, this branch of economics was concerned with the historical development of transportation networks, transport geography, the location of transport terminals, and traffic in urban areas. There was also a major concern for spatial variation in freight rates and the role of government regulation in the transportation industries. These latter topics dominated textbooks of the 1960s and 1970s. As early as 1955, the economist Troxel had noted that transportation was primarily a geographical problem. His text should be of interest to most transportation geographers today since it emphasizes the importance of location and space on flows, as well as the influence of flows on route location.

The network approach was the first major paradigm to emphasize a rigorous scientific approach to research in transport geography. It continues to be influential even today, with a growing interest in the use of GIS and remote sensing of networks. It also is a major component of the research of several scholars today (see Black, 1992a;
OTHER RESEARCH PARADIGMS

During the late 1960s and early 1970s there were major concerns regarding the way in which transportation was affecting society. Attempts were underway to save public transit. Studies of ridership by the young, the elderly, and various other groups were undertaken. Equity issues became a concern and studies of accessibility and mobility were undertaken. Rimmer (1978) tried to redirect the field to what he called a “humanistic transport geography” which resulted in studies of choice of mode, choice of route, and so forth. Much of this work was driven in the United States by concerns over relevance, but as noted elsewhere “it did little to advance the field, since it tended to ignore theory development” (Black, 1989, p. 317).

The development of this social-behavioral research paradigm had slowed by 1975. It was followed by a concern with regional transport systems brought on in large part by the move toward transport deregulation as well as by energy and environmental concerns. The earliest federal deregulation legislation in the United States was enacted in 1973 for the East and the Midwest. It was enacted in response to the 1971 bankruptcy of the Penn Central and other railroads. General railroad deregulation legislation followed in the Staggers Rail Act of 1980. In between these dates the airline passenger industry was deregulated in 1978. Deregulation of motor carriers and intercity bus transport occurred in 1982. Numerous theses and dissertations examined the impacts of these legislative actions. This examination continues today, as some believe deregulation has gone too far, resulting in some areas of the United States losing mobility. The same is true in parts of Great Britain, which has seen its own series of deregulation actions. These have prompted suggestions of the need for re-regulation. Numerous transport geographers became involved in policy questions during this period (see O’Sullivan, Holtzclaw, Barber, 1979; O’Sullivan, 1980; Black, 1986). This interest in government policy continues today for many transport geographers.

The 1990s saw a growing interest by transport geographers in transport technology (Garrison, 1984; Garrison & Ward, 2000), infrastructure, intelligent transport systems (see, e.g., Haynes & Qiangsheng, 1993; Stough, 2001), and sustainable transportation. Probably the bulk of the transport geography research during that decade fell under the last of these themes. Transport infrastructure consists of all the facilities that are used to provide transport services and includes, among other things, highways, streets, and roads; railroad tracks and trestles; runways, terminals, and transit facilities. Creating “intelligent transport systems” involves the use of advanced technologies to increase the efficiency and safety of our transport operations and networks. A “sustainable transport system” is one that meets today’s transport needs and is expected to meet the needs of future generations. For various reasons our current transport systems are not sustainable.

Transport geography research being undertaken today is not confined to the last three areas cited. Indeed, it would probably be possible to find research continuing in all of the major areas mentioned here. This is desirable. It also means that our interests are continuing to develop, which is good for the field of transport geography.

It should be recognized that each of the research areas pursued in the field of trans-
port geography from the 1950s to the end of the century was in response to an initial public concern that led to federal research funding. This is not unique to transport geography; the same pattern can also be found in physics, medicine, and many other fields. It is not necessarily bad either. There is considerable satisfaction in seeing a transit system begin that one has planned, or subsidies provided to rail lines identified by your research as worthy of support, or participating in the Penn Central reorganization—the largest corporate reorganization ever undertaken up to that time. But these activities do seem to take us away from further development of the field of transport geography, or do they? Perhaps it is best to have a field whose members have skills that can be applied to contemporary problems, even if such applications slow the field’s conceptual and theoretical development.

**OVERVIEW**

The remainder of this part includes two more introductory chapters. In Chapter 2 we briefly examine the history of transportation development. This will place much of what has occurred in transport geography in a context that makes it more understandable and will also clarify how we got to our current position. Our emphasis is on the United States, but we also make passing references to developments in Europe and elsewhere. In the U.S. case, development has occurred in the last 400 years and most of this development is documented; developments elsewhere in the world occurred during an era when documentation was unusual, and as a result it is difficult to follow. The exceptions to this are the development of some of the roads of the Roman Empire and of the Incas of South America. Our knowledge of some of these systems is due to archaeological research.

Chapter 3 examines current transport systems and trends in travel and transport. In this chapter we take stock of what is occurring today, which will delimit the nature of current transport problems in the world. Again, the primary focus will be on the United States and Europe, but we also examine some problems and trends elsewhere in the world.

The chapters that form the remainder of this text fall into five parts. In Part II, on network analysis, we examine the basic elements of networks, their nodes and links, and examine how their attributes can be measured. In Chapter 5, we give some attention to how networks can be placed in a form that allows analysis. Basic notions of connectivity, accessibility, and matrix representation are treated, as are measures of these and the structure of these networks. Part II concludes with an examination of the location of transportation routes (Chapter 6). Although location is fundamental to geographic studies, it has not received the attention it deserves in transport geography.

Part III, on flow analysis, begins with Chapter 7, which examines trade and commodity flows between different areas using the ideas of Ullman and moves on to discuss some elementary models of trade that have appeared in the literature. Spatial price equilibrium and some ideas regarding the stability of flows over time are also presented here. But there are other methods of flow analysis, which are the focus of Chapter 8. Included are discussions of transaction flow analysis, optimal flow systems, factor analysis of flow matrices, and network autocorrelation analysis.

Often we don’t know what the “demand” for movement is, so it is necessary to estimate this demand. This is referred to here as the “prediction problem of flow genera-
tion,” the subject of Chapter 9. This basic question must be answered if we are to look at flows within a nation or a metropolitan area. In some cases travel demand can be easily estimated, but in other cases the problem becomes very complicated—as we will see.

Chapter 10 of the flow analysis part examines spatial interaction—for example, the movement of people between places. It begins with a model where distance plays no role and moves on to the case where distance influences flow. The use of basic gravity potential models applicable to problems having a single origin or a single destination are examined, as is the use of gravity models for estimating all possible flows between a set of places, states, or countries. Several different gravity models are discussed in terms of their accuracy and logic. Also discussed here are the use of neural network flow models and some other flow models that are worthy of consideration.

Of course, understanding the amount of flow between places does not necessarily tell us how it will move between these places. This is the subject of Chapter 11, the last chapter in the flow analysis part of this book. Here we introduce the use of choice models, models that predict the modes or routes that flows will take. These are basic geographic questions wherein we try to understand the manner in which people and shippers evaluate their “costs” of spatial separation.

Part IV addresses the reality that many of the problems examined by transport geographers today have an impact on policy or are themselves impacted by policy (Chapter 12). Many of the goals of public policy in the transport sector create impacts that are spatial. The intent is to have positive impacts, but this is not always the result. In order to minimize adverse impacts we get involved in transport planning, which we also examine in this part (Chapter 13). In some cases planning actions may result in negative impacts. Methods of analyzing these negative impacts are reviewed here (Chapter 14), as are specific impacts on the environment (Chapter 15).

A final topic covered in this part is the interrelationship between transportation and development (Chapter 16). In the developed world transport investments are often used to stimulate the development of specific areas. In some cases these efforts are successful, but in other cases they fail. What determines success and failure in these cases? Is it reasonable to think that a transport investment can change the economic future of an area? These and other questions are examined for both the developed world and the developing world.

Part V (Chapter 17) addresses the use of geographic information systems (GIS) in the field of transport geography. GIS makes possible sophisticated analyses by a researcher that would have required substantial research funding two decades ago. It gives the researcher the capability of handling extremely large problems and examining numerous alternatives and outcomes. Although one cannot learn GIS in a chapter, the intent here is to introduce the subject and at least provide a platform for further work. Also examined here are some applications of remote sensing in the transportation area and their integration into GIS.

Current societal trends, congestion, and sustainability form the focus of Part VI. Significant changes occurring in today’s global society have impacts on transport (Chapter 18). We have an increasing number of single-parent households, which nearly doubles urban travel demand; larger numbers of women are joining the work force, thereby adding to the vehicles that congest our highways; the elderly are becoming a larger proportion of the population with travel needs they often cannot meet. The United Kingdom and the United States have undertaken welfare reform without any clear recognition of
the transportation implications of these actions. Also included in this general area are moves toward deregulation of the transport sector, privatization of that sector, and the controversial moves toward globalization. Globalization of industry results in longer and longer shipment lengths for products. Trading partners are no longer contiguous, which results in additional transport inputs to the production–consumption process. We examine these and other changes and their implications for trade and transport.

Congestion (Chapter 19) is a significant problem throughout the developed and developing worlds. There is a growing recognition in the United States that highway construction has its limitations, and that therefore actions must be taken to control the congestion on existing facilities. In the developing world we are seeing rapid motorization. The use of these vehicles exceeds the capacity of the existing road network, resulting in significant congestion levels. Congestion is the subject of the second chapter of this part.

Sustainable transportation (Chapter 20) is a notion that slipped into the literature of transportation geography in the late 1980s and has remained. Its origins were in the environmental area, but it is viewed in a broader manner than that today. A chapter on this topic defines the term and its components and suggests how it could be measured. It is apparent that although we would like to see transport systems that are sustainable for this and future generations, that may very well mean we must be less mobile. Unfortunately, most countries of the world do not want to give up any of their mobility and many more countries are interested in increasing their mobility. The chapter develops an index of sustainable transport that is coupled with the notion of potential mobility and applies this to more than 100 areas of the world. The chapter illustrates not only how to go about constructing an index, but also what such an index can tell us about this notion of sustainability and what it means for future mobility.

Part VII (Chapter 21) looks ahead to what can be expected for transportation in the coming decades. Chapter 21 examines different scenarios of the form that transportation will take within the next two to three decades in the developed world. The transportation systems of the future may be simply an extension of what we currently have, with all of the problems simply worse than they are at present. Or we may see some significant actions taken to improve the current situation. It has been said that all our transportation problems are solvable, and this is true. The problem is that we often do not have the will or the resources to change. Two people in every car would nearly solve congestion problems, and expensive hydrogen fuel would eliminate pollution, but people are not anxious to do the former and the price of the latter makes us hesitate. The future transport world with its problems (and solutions) is rarely a subject of transport geography textbooks. Admittedly, the subject is often full of conjecture and colored by the author’s biases, but even this is relevant if it promotes discussion. These are problems the readers of this volume will experience through most of their lives.

Just as important as these ideas are questions of what will remain as significant research problem areas in transportation geography in two or three decades. My final chapter will make some suggestions in this area.