Chapter 20

ENVIRONMENTAL IMPACTS

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Rationales for the development of rapid transit systems in recent decades have been based largely on reducing the adverse effects of overreliance on the automobile. These adverse effects of the auto and its associated roadway facilities have been substantially environmental. Highest in priority are urban air quality and global upper-atmosphere equilibrium, but other concerns include the destruction of homes, neighborhoods, jobs, and other valued urban places, as well as natural habitats and environments, for the construction of freeways and other large-scale facilities.

Further effects of the auto itself include noise, vibration, visual blight, and intrusion, as well as excessive energy use. Dependence on the automobile has also been a major force in urban sprawl, with freeway construction encouraging scattered low-density residential development in suburban areas.

Transit, in one form or another, has often been seen as a means of minimizing such environmental consequences. It is reasoned to do so by reducing auto traffic (particularly commute traffic) generally and avoiding further construction of urban freeways, at the same time encouraging more intensive activity at transit-oriented nodes. In so doing, it is hoped that transit might particularly help to reduce suburban sprawl and strengthen the centers of older cities, now increasingly congested and difficult to reach by car. Transit is also seen as more energy efficient and less polluting than the automobile on a per trip basis. Implicit in these objectives is a vision of transit as a contributor to the humane city. This ideal is typically seen as small in scale, with

*The authors wish to dedicate this updated chapter to the memory of the late Professor Donald Appleyard of the University of California's Institute for Urban and Regional Development. Professor Appleyard was a co-author of the original version as it appeared in the first edition, and much of his unparalleled understanding of this subject is still reflected in this updated chapter.

intensely active, pedestrian-oriented public environments.

These hopes may or may not be justified. However, they have been powerful enough to generate widespread and enthusiastic political backing and even considerable public financial support for new transit systems in many cities. In the 1980s this support was tempered by fiscal constraints, although signs of increased public backing of transit-development taxes began to emerge again as traffic problems and environmental concerns intensified. This chapter's purpose is to look at some of the faces behind those hopes—the nature and scale of environmental impacts, for good and for ill, which seem to occur when a major new transit system or component is provided.

ENVIRONMENTAL IMPACT ASSESSMENT

As proposed transit solutions appeared during the 1960s and 1970s, a methodology of environmental impact assessment emerged to aid in their evaluation. Much of this methodology was developed in response to federal environmental protection legislation, as will be discussed later. Its intent is to assess the environmental benefits and costs of new projects and systems in a systematic, comprehensive way. This chapter will outline some of the issues, problems, and models involved in environmental impact assessment, as well as the empirical evidence and other information currently available on such impacts.

ISSUES IN IMPACT ASSESSMENT

A number of issues that have been raised over the years provide a general indication of the scope of environmental impact concerns. Some of these deal with definitions of the key concepts involved: What is the environment? What is an impact? Which impacts should be considered? What criteria should be used in their evaluation? How do direct or immediate impacts relate to indirect or remote impacts?

Another set of important issues addresses to the nature of impacts and how they occur: What are the relationships among environmental, land-use, political, and economic impacts? How are impacts likely to change with time? What are the primary causes of impacts? How reliably and precisely can impacts and causes be identified?

Finally, other issues focus on the policy implications of environmental impacts: How do the impacts of public transit systems compare and combine with those of other transportation systems and strategies? How can impacts be ameliorated and controlled by policy and planning decisions? How does current knowledge of impacts affect the selection of recommended policies? How might improved accuracy of assessment affect this?

IMPACT GENERATION

Environment is a tricky term. Because of its popularization, it is often loosely and inconsistently used. Perhaps its most popular connotation is also its narrowest and most misleading: that of the wild or natural flora and fauna or, only slightly more broadly, all natural ecological components, including atmospheric and waterway systems. In dealing with the environmental effects of public transit in urban areas, such definitions are especially misleading because most elements of the natural environment tend to be relatively little affected.

A properly relevant definition must center on human survival and advancement. This does not mean that protection of the nearby natural environment is unimportant, but rather that other environmental concerns are at least as relevant, if not more relevant, in an urban system. Our current popular concern with even the natural environment is for the most part based on a belief in its importance in ensuring a healthy continuation of the human species, rather than simply protecting flora and fauna for their own sake. Thus, for purposes of transit system development, the relevant environment must be defined much more broadly. It must include all the physical components of the world, be they natural or man-made, local or global, on which people must depend in their everyday functioning. It is this *human* environment, in all its complexity, that is to be protected and advanced.

Environmental *impact is* simply any change (in this case, induced by transit) in this broadly defined environment. Impacts occur in a complex causal pattern, with initial impacts combining and sometimes jointly leading to others (see Fig. 20-1). An initial change in the environment (for example, introduction of a transit system) creates a set of *emissions*, such as sound, physical mass, movement of vehicles, and the flow of patrons. These emissions lead to some *direct* impacts on various aspects of the physical environment (for example, changes in community noise levels), which may in turn generate *indirect* impacts (for example, changes in traffic levels, activity patterns, demographics, or land use). Emissions also can be *magnify ed* or *mitigated* by intervening features, such as sound barriers, distance, or elevation, which modify the impacts on surrounding populations.

The impacts of a change can be assessed (either before or after implementation) only by comparison to some base case. This base case may be, for example, the "do-nothing" alternative, or an "all-bus" scenario (to compare against a rail system), or a "transportation system management" (TSM) alternative (implementing more efficient use of existing facilities through minor operational and infrastructural changes). Either the base case scenario or the change scenario is necessarily hypothetical, and in many cases, both are. Impacts are, thus, defined as the specific differences between the two cases. This is especially essential for indirect impacts, which often depend on the estimated difference in land-development rates and patterns between the base case and the proposed change. Transportation-land use mathematical projection models are not

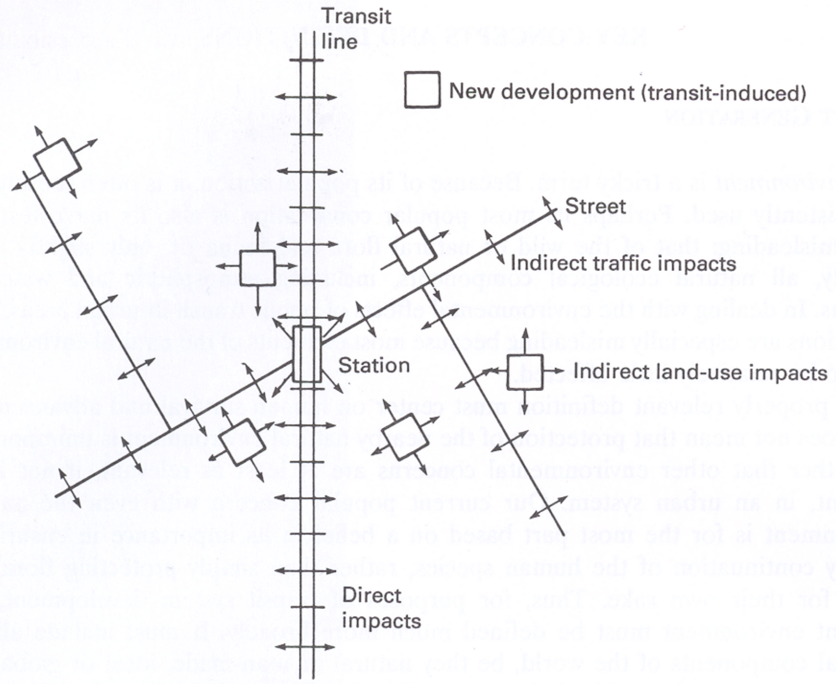

Figure 20-1 *Direct and indirect environmental impacts.*

very satisfactory for this purpose. Whether they or some mechanically less complex approach is used, judgmental adjustments must be applied to the results to ensure consideration of important subjective factors.

Transit systems have *internal* impacts on travelers and *external* impacts on the larger environment. Transit's role as an environment for its users is in many ways as important as its influence on its own external environment and the people who depend on that environment. This chapter will concentrate on external impacts; the traveler's environment is discussed in Chaps. 18 and 22.

An important aspect of environmental impacts is their typically *dynamic* nature. These environmental effects occur not all at once but tend to change as time passes, since a transit system inevitably changes in its impact-causing attributes. Planning and anticipation lead to construction, a substantial period of change that culminates in a start-up phase of operations. Construction, too, may last for several years, with gradual changes until a stable operational condition is reached. Finally, some impacts, such as demographic or land-use changes, may not be visible for many years after operations have stabilized. Each stage has its own environmental impacts, which can differ dramatically in type and consequence.

Impacts can be positive as well as negative. Indeed, if the environmental impacts (broadly defined) are on balance negative, the system should not be built. The introduction to this chapter suggested some positive impacts that can be achieved, including reduced energy consumption, improved air quality, improved accessibility of businesses, improved mobility of residents, and a more structured, compact urban form.

RESPONSE TO IMPACTS

The *perception* and *evaluation*, of these impacts and the subsequent behavioral *response* by persons who are affected are the culmination of the environmental impact process. These terms are used in the psychological rather than the colloquial sense to encompass all the reactions of the human organism, including unconscious as well as conscious elements. Thus, an effect on air quality may lead to illness, and noise may cause emotional distress.

Such behavioral responses can lead to further changes in perceptions and evaluations in a cyclical fashion. The degree of behavioral adaptation (such as moving to the back of the house or not allowing the children to play on the street), psychological adaptation (readjusting expectations), environmental modification (building fences or installing soundproof insulation), or public action (participating in political opposition) that the individual finds necessary can profoundly affect perceptions and evaluations of the source of the impacts—in turn possibly leading to other behavioral responses (such as deciding to move).

IMPACT AS A PROCESS

Many of the concepts and definitions just described can be better understood diagrammatically. Figure 20-2 is one form of such a presentation, indicating linkages between the sources of impact, the impacts themselves, their effects on people, and a variety of actions taken in response. Note that the process is continuous, involving substantial feedback, rather than a one-time adjustment of impact. Although the figure emphasizes operational (postimplementation) impacts, those related to the planning (preimplementation) and construction (implementation) phases of a transit system's life fit equally well.

These environmental impacts may fall on several *population groups.* Adjacent residents are usually of greatest concern and may themselves differ in exposure or sensitivity. Others include those who work, play, or travel near the system's facilities and the general population of the region. All must be considered in impact evaluation.

Direct impacts, particularly those occurring only during the stable, full-scale period of the system's operational life, are relatively easily assessed, but may in some cases actually be less important than some of the indirect impacts arising from the system's long-term effects on land use. Likewise, the disruptive impacts of construction may produce lasting effects more serious than any operational impacts, and start-up and shakedown operations may have impacts more severe than those of later stable service. Consequently, the evaluation of impact should be longitudinal (that is, over the life of the system), rather than a cross-sectional "snapshot."

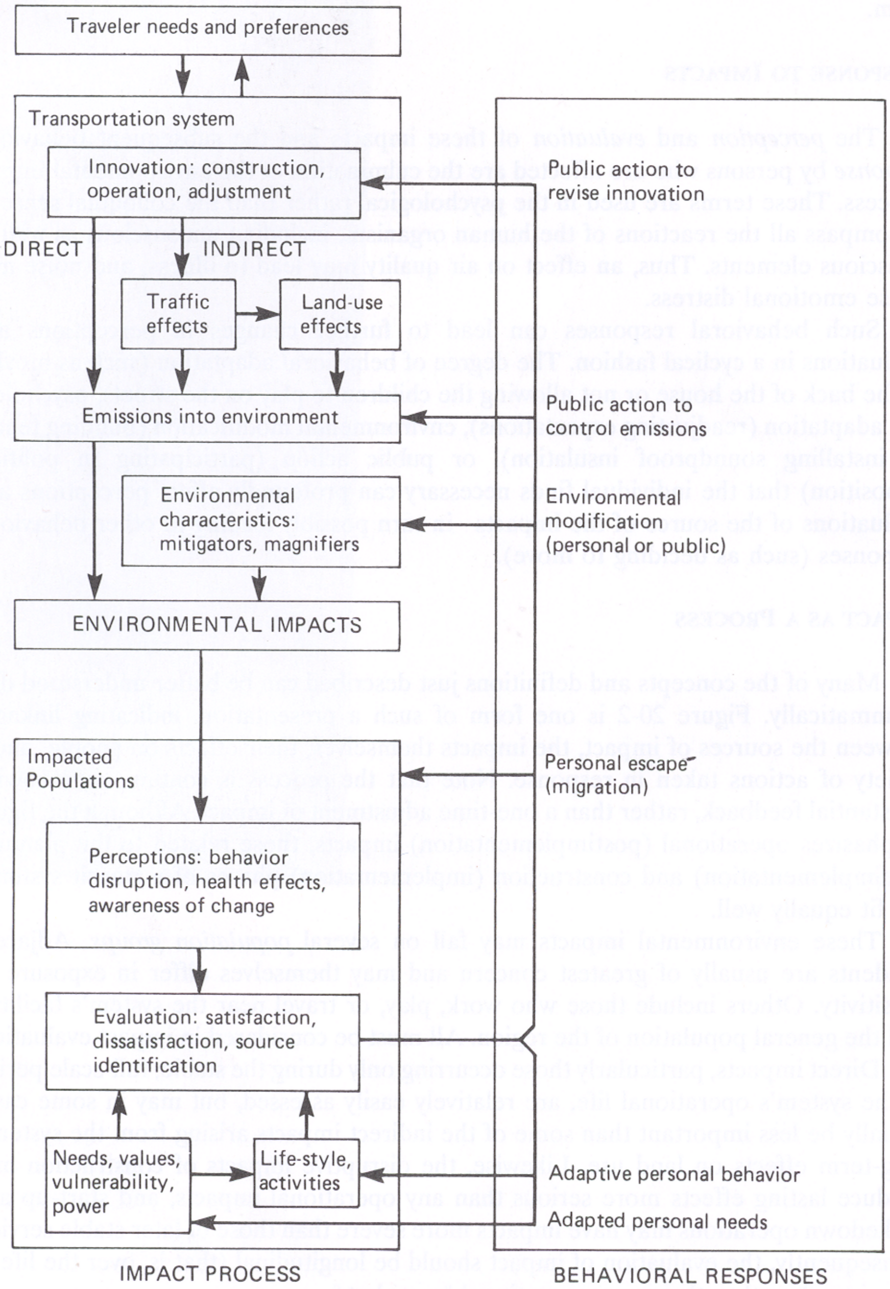

Figure 20-2 *Socioenvironmental impacts of transport innovations.*

THE PRECONSTRUCTION ENVIRONMENTAL IMPACT EVALUATION PROCESS

An evaluation of environmental impacts can take place during the planning, construction, or operational phases of the transit system. For the latter two phases, the evaluation can be either concurrent (conducted as or shortly after the impacts occur) or retrospective (conducted some time after the impacts occur). During the planning phase, however, an evaluation can only be prospective—that is, conducted before any direct impacts are experienced and therefore based on predictions rather than actual measurements. There can, however, potentially be real *indirect* impacts during the planning phase, for example, on property values near proposed transit stations. The *Metro Rail Before-and-After Study*, conducted for the Southern California Rapid Transit District by its planning consultant, developed regression models to predict property values before a Metro Rail alignment was finalized. These "before" models were then applied to sales taking place after the alignment was adopted. Analysis of the residuals from the application of these models led to the conclusion that proximity to Metro Rail stations contributed modestly to an increase in property values—even though completion of the first segment of the system was still years away.

The prospective nature of a preconstruction environmental evaluation does not make it less significant. In fact, the planning-phase evaluation is arguably the most important one of all, for several reasons:

1. It can allow potentially serious negative environmental impacts of the selected alternative to be identified and mitigation measures to be developed beforehand, rather than after the fact.
2. It can sometimes lead to the selection of an environmentally superior alternative that would not have been identified or selected otherwise, including cases in which environmental considerations are among the reasons a proposed action is ultimately dropped altogether.
3. The public review and comment process associated with the evaluation provides the opportunity for substantive citizen input before committing to an expensive transit system. This input can lead to either of the first two outcomes—that is, implementation of mitigation measures or a different alternative.

An environmental impact evaluation is required by the federal government and most states as a condition for receiving federal or state funding, respectively, for the project. An overview of the federally mandated environmental impact review process is given in this section. To help distinguish between similar but not identical terminology (for example, EIS versus EIR, NOI versus NOP), parallel concepts used in the state-level review process by the state of California are mentioned where appropriate; California is cited because of the adoption of many of its terms and methods by other states. Terminology and process may vary somewhat from state to state, but the general concepts are broadly applicable.

BACKGROUND

The National Environmental Policy Act of 1969 (NEPA) instituted the envirorонmental evaluation process for all new actions (including, for example, water treatment plants and oil drilling operations, not just transportation) involving federal land, funding, or control.1 Many states passed additional legislation, such as the California Environmental Quality Act of 1970 (CEQA), to cover projects with state or local involvement and major private projects. Subsequently, federal agencies developed regulations and guidelines for the specific application of NEPA to actions under their control. In particular, the U.S. Department of Transportation (DOT) has prepared guidelines that must be followed if a transportation project is to receive federal funding.2 Both the NEPA and the DOT guidelines are included in the discussion following.

TYPES OF ENVIRONMENTAL STUDIES

As might be expected, different levels of environmental scrutiny are required depending on the size and potential impacts of a proposed project. DOT has defined three classes of transportation projects:

1. Class 1 projects are large-scale transit systems (such as new or extended fixed-guideway construction) that will clearly have environmental impacts. For these projects, an *Environmental Impact Statement (EIS)* must be prepared. (In California and elsewhere, the comparable state-level document is referred to as an *Environmental Impact Report*, or *EIR;* it is permissible, and usually most efficient, to prepare a joint EIS/EIR as long as both sets of requirements are satisfied.)

2.Class 2 transportation projects are those that clearly will *not* have environmental impacts. Examples include operating assistance to transit authorities and maintenance on existing rights-of-way. In these cases, also called *Categorical Exclusions (CEs),* no environmental review is required.

3.Class 3 projects are those whose environmental impacts are, a priori, uncertain. Examples include transit terminals, park-and-ride facilities, and administrative facilities. For these projects, an *Environmental Assessment (EA) is* required, to determine whether or not the environmental impacts will be important. (In California and elsewhere, the state-mandated comparable report is called an *initial study;* again, it is common to see joint EA/ISs.) EAs are sometimes called *Environmental Impact Assessments (EIAs).*

If some important environmental impacts are found by the preliminary EA, then an EIS is required for the project. If not, then the lead federal agency issues a *Finding of No Significant Impact,* or *FONSI* (the comparable determination in an Initial Study is called a *Negative Declaration, or ND).*

KEY ELEMENTS OF THE ENVIRONMENTAL REVIEW PROCESS

This section describes some key elements of the environmental review process, including some observations drawn from real-world examples. Most of the concepts in the following subsections apply generally to both EAs and EISs, and to a state-level review as well as the federal review.

Selection of Lead Agency

For a proposed action subject to environmental review, the NEPA guidelines require the identification of at least one federal agency to serve as the *lead agency*. The lead agency bears the responsibility for ensuring the adequacy of the environmental documents and process and issues the *Record of Decision (ROD)* regarding the proposed action (the comparable state-level finding in California is called the *Notice of Determination')*. In some cases, there is a single logical choice for the lead agency designation. In other cases, the choice is not so clear. For a proposed high-speed rail line connecting San Diego and Los Angeles, California, for example, the Federal Highway Administration (not the Federal Railroad Administration) was named the lead agency, because the rail right-of-way would follow an interstate highway (I-5) for much of its alignment. The California Department of Transportation (Caltrans) was selected as the state lead agency, although the California Coastal Commission (since the route fell partly within the commission's jurisdiction) and the California Public Utilities Commission (because the proposed service would require a *Certificate of Public Convenience and Necessity* from the CPUC) were also logical candidates.3

At least one federal agency must be designated the lead agency. Other federal, state, or local entities may be joint lead agencies in certain cases. Any public body that has at least partial jurisdiction over the proposed action and is not a lead agency is considered a *cooperating agency*. The selection of the lead agency is usually determined by mutual consent, but administrative procedures are prescribed for resolving disputes over who should be lead agency or disagreements among lead and cooperative agencies.

Potential Impacts and Potential Alternatives

The proposed action must be evaluated for its impact in a variety of environmental areas, such as noise, traffic, land use, aesthetics, water resources, biological resources, historic properties and park lands, and construction. A list of the 19 specific elements described in the Urban Mass Transportation Administration's (UMTA) *Guidelines for Preparing Environmental Assessments4 is* provided in Appendix A.

An EA or EIS need not explore each potential environmental impact in depth. Rather, *a scoping process* takes place between the lead agency and the applicant, in consultation with other affected parties, to identify particular issues that are likely to be most important. The environmental review then focuses on these issues. If a proposed alignment does not pass through any wetlands, for example, no study of that element is needed. On the other hand, some topics not specifically cited in the guidelines may be important in some geographical areas. For example, the evaluation of passenger safety for a major transit project in California would likely require an assessment of seismic risks and mitigations.

The environmental process should identify mitigation measures for the objectionable impacts of the project. It should also briefly discuss alternatives to the project, including "alternative locations and designs; alternatives with different characteristics, but that may achieve similar benefits and are preferable from an environmental standpoint; alternatives not within the jurisdiction of UMTA, if appropriate; and the ‘do-nothing' alternative."5 The document should discuss the other alternatives considered and why the proposed action was chosen over the other options.

Public Review and Comment

It is the intent of NEPA that no environmentally significant project be approved without ample opportunity for public review and comment. There are more formal requirements for public input on an EIS than on an EA. The EIS process opens, for example, when the lead agency publishes in the *Federal Register* a Notice of Intent (NOI) to prepare an EIS (for the state-level process in California and elsewhere, a *Notice of Preparation*, or NOP, is circulated). The NOI also sets the time and place for the first scoping meeting and provides contact information. In addition to the *Federal Register*, the NOI should be published in local newspapers and through other appropriate media and sent directly to those individuals and organizations known or expected to have an interest in the proposed action. The same is true of other public notices associated with the environmental review.

When the draft EIS (DEIS) is finished, a notice of publication is placed into the *Federal Register*, and the document is circulated for public review and comment. The final EIS (FEIS) contains the DEIS, the comments received, and the response to those comments (including any new mitigation measures). Notice of publication is also required for the FEIS. The public is allowed at least 45 days to comment on a DEIS. A Record of Decision (ROD) may be signed no sooner then 30 days after the publication of a FEIS or 90 days after the publication of a notice for a DEIS, whichever is later.

Besides allowing the opportunity for written input from the public, UMTA requires that public hearings be held during the scoping process and during the circulation period for a DEIS.

Supplemental EISs

The need for a *Supplemental Environmental Impact Statement (SEIS)* arises if (1) the proposed action is changed in a way that could pose significant environmental impacts that have not already been evaluated or (2) new information is obtained or new circumstances arise relating to potential environmental impacts. A SEIS can be prepared for a DEIS, a FEIS, or a previous SEIS. If more than 3 years pass between publication of a DEIS and an FEIS or between publication of an FEIS and taking major action to advance the project, either an SEIS or a new EIS is required.

For the Los Angeles Metro Rail system, an FEIS was approved in December 19836 and construction on the first segment began in September 1986. In March 1985 an explosion and fire occurred near the intersection of Third Street and Fairfax Avenue—an area through which the Metro Rail subway was to pass. The cause of the explosion was determined to be the accidental combustion of naturally occurring underground methane gas. Because of concern about the hazard posed by the gas, the U.S. Congress (in an attachment to Public Law No. 99-1980, December 19,1985) prohibited tunneling through the areas identified as high risk. This action necessitated consideration of new alignments, including aerial configurations through the high-risk areas and routes that circumvented the areas. These alignments were evaluated in the *Supplemental Environmental Impact Statement/Subsequent Environmental Impact Report*, completed in July 1989.

CONSTRUCTION AND POSTCONSTRUCTION IMPACT EVALUATION:THE BART CASE STUDY

The BART Impact Program was a comprehensive postconstruction study of impacts of the San Francisco Bay Area Rapid Transit system, sponsored by the U.S. Department of Transportation to provide design guidance for future transit systems. Conducted in the mid-1970s, it encompassed impacts on travel patterns and modes, economics, land use, and social groups, as well as a landmark study of environmental impacts. This section will summarize these effects and add observations on impacts since the BART study was completed. A following section will deal with impacts of other transit modes, using the BART data as a point of departure.

BART's size, variations in design, and diversity of surroundings provide a wealth of specific impact conditions, including many similar to those found on other recent transit systems and extensions. At the same time, the BART system overall is not representative of most other conventional rapid rail systems. Its role is primarily that of connecting low-density suburban residential communities in an auto-dependent metropolis to a downtown center, rather than facilitating movement within the densely populated central city.

BART's lines are therefore radial, and they extend much farther into the suburbs than do other systems in cities such as Toronto and Montreal. Its lines and stations are also primarily aboveground (except in the major downtown areas it serves in San Francisco, Oakland, and Berkeley), in contrast to the more subway-dominant configurations of the Toronto and Montreal systems. All these characteristics will be reinforced by the several new radial extensions of the BART system now being planned. These differences have important implications for overall systemwide environmental impact, although the impacts of specific BART segments and stations may be similar to other systems.

THE NO-BART BASELINE

In defining impacts, as already noted, it is essential to have a baseline or "no-build" situation with which to compare. A major environmental benefit, for example, would be the avoidance of construction of additional urban freeways because of the transit system. The difficulty of identifying such a one-for-one substitution, however, should not be underestimated, since the two tend not to serve all the same purposes and also because many other factors are involved in the decision to build a major road.

In BART's case, there was considerable discussion as to whether BART had been instrumental in preventing construction of a very large and potentially environmentally disruptive bridge parallel to the San Francisco—Oakland Bay Bridge. An analysis of the events of that period indicated that the proposed bridge would probably have been stopped for other reasons, so it was not included as a component of the "no-BART" alternative. Clearly, this critically affected the outcome of the BART impact analysis. The "no- BART" scenario against which BART was compared emphasized the use of more express buses on existing roads, which had no discernible environmental effects. As a result, the net environmental impacts attributed to BART, although small, were largely adverse, even though this might not be so elsewhere. Obviously, such a base case must be carefully defined and justified (as it was with BART) to allow a fair and credible impact analysis.

CONSTRUCTION IMPACTS

In an absolute sense, the adverse effects of the rapid transit construction process can be substantial. With BART as well as the Washington, D.C., Metro, the Los Angeles Metro Rail, and other relatively new systems, the most serious effect appears to be that of the disruption of traffic and trade along streets subjected to long periods of open-cut subway construction. In some cases, subway construction on downtown streets was under way for over 5 years, with some indications of large losses in trade for businesses along the right-of-way (see Fig. 20-3). Small businesses were apparently most affected; it has been asserted that many did not survive to enjoy the benefits of the completed subway system, although documentation on this point is sparse. Experiences elsewhere are similar; in Amsterdam, for example, construction of the metro system was responsible for the demolition of a historic neighborhood, causing serious community conflicts.

Housing dislocation is another significant problem. Although the BART system is almost entirely sited along prior transportation rights-of-way such as railroads and freeways, research indicates that over 3000 housing units were taken for the construction of the 71 mi (114 km), 34-station initial system. Many of these were at suburban station parking-lot sites, which are up to 8 acres (32,400 m2) in size and often in residential areas. Others were concentrated along routes in which the existing right-of-way had to be widened to accommodate the trackway (see Fig. 20-4). Even this large number, however, is small when placed in the perspective of the system's length (an average of well under 50 units/mi or 31/km) and in comparison with urban freeway

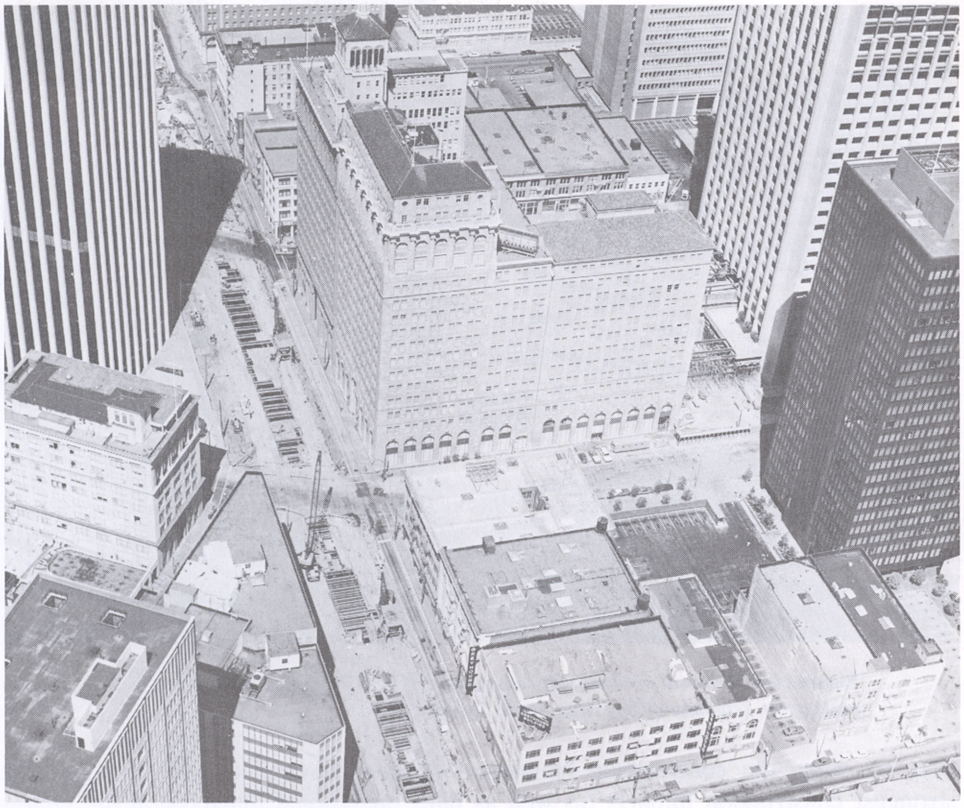

Figure 20-3 *Long-term closure of Market Street in downtown San Francisco for BART subway construction. (courtesy of Bay Area Rapid Transit District)*

construction requirements (often 200 to 500 or more units/mi when constructed through existing urban areas).

Construction effects of *aerial and at-grade trackways* are relatively benign, owing to their simplicity and relatively rapid construction. Even this level of activity, however, is at variance with the quiet character of many residential areas and led to many complaints during BART's construction. Construction of *tunneled* subway lines, as in Montreal, is of course least disruptive except at points of access and removal of material. *Open-cut* subway construction, particularly at stations, is most disruptive; other problem areas include suburban station sites, particularly those with parking lots, which tend to be used as staging areas and generate substantial truck traffic and noise.

Major efforts needed to ameliorate such impacts include the use of more rapid subway construction techniques, careful planning of interim traffic and transit reroutings, and an intensive program of public relations (such as BART's) to inform nearby residents and others of impending activity and to respond to complaints. Finally, it must be recognized that minimization of land acquisition and its attendant disloca-

Figure 20-4 *Removal of homes for construction of BART Concord Station and parking lot. (courtesy of Bay Area Rapid Transit District)*

tion, by doing the construction on narrow rights-of-way, necessarily produces the strongest construction impacts (as well as later operational impacts) on the nearby residences and businesses that might otherwise have been taken in right-of-way acquisition. This trade-off must be recognized and carefully assessed in system planning.

Early Operations Impacts

The early operations period of some new rail rapid transit systems has been characterized by a variety of difficulties in achieving both reliable system operations and harmony with surroundings. BART's initial problems with the mechanical reliability of its trains and automatic train control system, for example, resulted in a lengthy period of environmental impacts of somewhat less intensity than those that occurred later when the system's trains were running at more frequent intervals and on weekends. Most important among such impacts is train noise along the system's elevated lines; this was at first a moderate problem in the one to two blocks in quiet residential areas nearest the lines, but affected more areas with full operations.

This initial operations period is also characterized by patronage levels substantially lower than those likely to be reached after service is improved. As a result, impacts related to patronage increase. The most important of these are related to traffic, parking, and connecting bus service at the suburban stations. In the case of BART, even in the initial operations period, parking overflowed from many of the station lots onto adjacent streets. Similar patronage-related impacts have been experienced elsewhere, notably on the Toronto and Montreal systems and the Philadelphia area's Lindenwold line.

These change-prone impacts are typically those attributable to the system's *operations; i*n contrast, those due to *its facilities* are likely to be relatively stable over time. Included among these are impacts on the visual environment and natural ecology and neighborhood effects such as closing of streets and paths across the right-of-way. These stable effects and other impacts of full operations are discussed in the following section.

IMPACTS UNDER STABLE FULL-SCALE OPERATIONS

The major finding of the BART study of environmental impacts was that the system's effects are generally small and will continue to be so. Despite greatly expanded patronage, more intensive service, and some deterioration of the original level of system maintenance, this conclusion still appeared to hold true more than a decade later. This applies to regional effects, such as reduction of auto air pollution, as well as localized impacts both at the stations and along the lines. Exceptions are noted in the following paragraphs, along with other details that may be applicable to new systems proposed elsewhere.

BY 1990, BART patronage had doubled since the completion of the BART Impact Program; parking lot expansions and improved feeder bus service were required during the 1970s and 1980s as patronage increased. In the 1990s, BART is involved in a $90 million parking capacity and station access improvement program, launched by the replacement of a 400-space portion of the surface parking lot at the El Cerrito Del Norte station with a 1300-space multilevel parking structure.7

BART'S effects on the region's air quality and energy use apparently continue to be very small, primarily because it is estimated to carry only 3% of the region's daily vehicular trips. In addition, much of its patronage is drawn from previous bus users rather than auto drivers or passengers. The system, however, is now a prominent part of the San Francisco Bay area's image. The elevated lines and trains are seen from a number of freeways, arterials, and residential areas, and the system is internationally known (see Fig. 20-5). It has, therefore, become something of a tourist attraction. Older and more closely spaced subway systems, such as those in London, Tokyo, and Paris, have for many become the primary mode of structuring the city's image, since they are simpler and easier to use than the aboveground street networks; BART, however, is much more thinly spread across the region and probably plays a much less significant role in this regard except to help patrons comprehend very large scale spatial relationships (that is, outer suburbs to inner city, rather than the city itself).

BART'S effects at stations are mixed. Impacts attributable to the downtown subway stations have been almost entirely positive as a result of the new plazas created around the stations and the street beautification projects that were undertaken by cities in

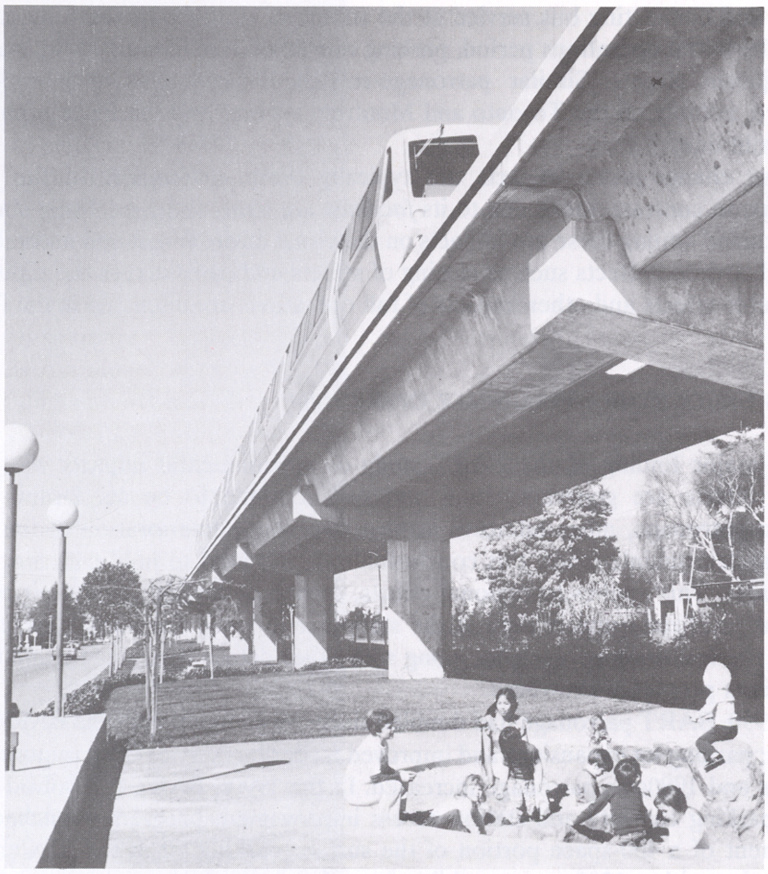

Figure 20-5 *BART train on typical elevated trackway in residential area, with experimental "linear park." (courtesy of Bay Area Rapid Transit District)*

cooperation with BART (see Fig. 20-6). Many of these environmental improvements have created lively social meeting places. As is true for the entire system, crime has been a minor problem at these downtown stations. On the other hand, the coordinated planning of development around the BART stations has been much more limited than the multilevel pedestrian complexes that have been created around such stations as Place Bonaventure and others in Montreal, Shinjuku in Tokyo, or Insurgentes in Mexico City.

The suburban stations have not been closely integrated with new suburban centers, as at Vallingby near Stockholm or Senri near Osaka, Japan. At suburban BART stations, the large parking lots (some now expanded to over 2000 cars) are often beyond convenient walking distance from adjacent centers (see Fig. 20-7). The opportunity to create suburban pedestrian centers or to reinforce existing ones has, therefore, been largely lost. Many suburban stations could have been located much closer to or even

Figure 20-6 *BART station entrance plaza below street level in downtown San Francisco. (courtesy of Gruen Associates, Inc.)*

within already built suburban shopping centers. Cost, the private nature of these centers, and the fragmentary nature of urban planning around BART, which resulted in BART's inability to plan beyond the right-of-way, precluded such packaging.[8] Although there is still the future option of building on air rights over some BART parking lots, no such development has so far occurred due to the combination of high cost, lack of demand, and local community opposition.

As noted earlier, several parking lots were overfilled shortly after opening; others became so as patronage rose. Terminal stations are most affected. The severity of the problems caused by this overflow and the associated station-area traffic varies widely, depending on the station location and parking-lot access to major streets. In general, it is a significant problem in residential areas—probably the system's largest effect on its surroundings—but not elsewhere. At the same time, solutions, such as either lot expansion or construction of multilevel facilities, are most difficult in existing residential areas. In consequence, the planning of future BART extensions into less-developed suburban areas has included much larger parking lots at most stations to avoid the difficulties of expansion after the initial land acquisition and construction.

The BART Impact Program found few other station-area impacts, and little change has occurred since then. The visual effect of the stations was generally perceived by nearby residents as neutral or positive. Noise was slight. In general, nearby residents were found to be unhappy where there was an overflow parking problem and relatively happy otherwise. They seemed to discount most other effects. Finally, land value or land-use changes appeared to be virtually nonexistent when the BART

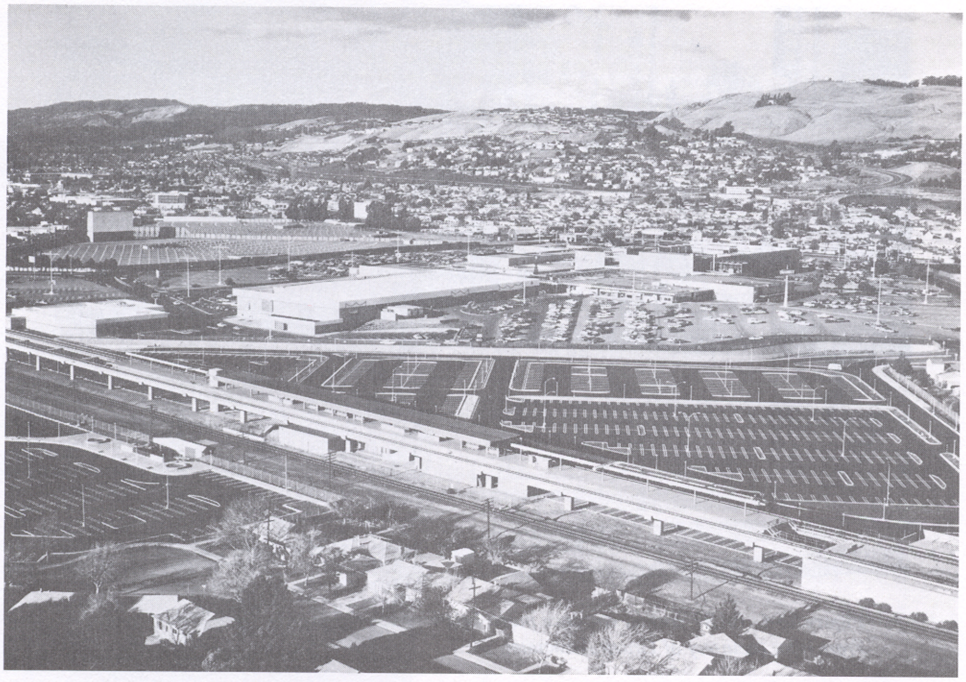

Figure 20-7 *BART station and parking lot separated from shopping center by fenced drainage channel. (courtesy of Bay Area Rapid Transit District)*

Impact Study examined them after 5 years of limited operations (apparently no newer efforts have been made to confirm this). For similarly short periods of operation, other recently developed systems have had similar experiences with station-area development, although Toronto is notable for its apparent intensification of land use over a longer period.

Impacts along BART's subway lines are nil where tunneled except around the stations, where large open excavations were necessary. Most cut-and-cover line sections were located in wide arterial streets, causing construction impacts, but limiting the numbers of dwellings taken. In the long run, these are the lines that have had most beneficial impacts, reinforcing and enhancing existing centers, such as Market Street in San Francisco and Shattuck Avenue in Berkeley. BART's 70 mi/h (113-km/h) trains on its aerial lines, however, despite their quietness relative to other systems, were judged in the original BART study to cause some noise problems for many residents living within one or two blocks. A reduction of from 5 to 10 dB(A) is required to eliminate this problem in most places. Sound-barrier baffles on the guideway could do this, although they would increase the presently acceptable visual bulk of the structure as well as its shadow effects and cost. Such barriers were actually built in some especially sensitive areas and have apparently been effective.

Future transit systems may find it necessary to mitigate potential noise impacts through even quieter trains, bulkier structures, wider rights-of-way, underground placement, or line locations outside quiet residential areas. Interestingly, however, even though the BART trains have grown progressively noisier over the years, there has apparently been no public complaint or other indication of increased problems with wayside noise impact, suggesting a higher than expected degree of adaptation by nearby residents and businesses.

The wayside problems identified in the BART Impact Program affect relatively few residents, since most of the BART aboveground trackway shares rights-of-way with other transportation facilities, such as freeways, arterial streets, and railroads (Fig. 20-8) It was found, however, that this is no guarantee of impact-free operation; where the system shares a little-used railway right-of-way, adjacent neighborhoods are not adapted to noise and suffer more than others. A 2-mi (3-km)-long landscaped strip (the "linear park" in Fig. 20-5) beneath the BART aerial structure in one such location was appreciated and actively used by local residents, but apparently did not lessen their unhappiness with the BART train noise. Along the at-grade lines, which are potentially dangerous because of the high-voltage third rail, as well as the high-speed trains themselves, protective cyclone fences now interrupt pedestrian flows, which freely crossed relatively unused railroads in some neighborhoods. This inconvenience has been offset by pedestrian bridges and is apparently only a minor concern. All in all, the use of prior transportation rights-of-way appears to be a useful factor in minimizing environmental impact.

Finally, in consideration of the major Loma Prieta earthquake in October 1989, it is appropriate to comment on the impacts of—and on—rapid transit systems in such events. Despite the 1989 quake's 7.1 Richter magnitude, the highest in Northern California since the 1906 San Francisco disaster, BART suffered virtually no damage. After a brief shutdown for inspection, the system was back in operation within a few hours after the shock. BART's underwater Transbay Tube, supplemented by a fleet of emergency ferries provided the only direct Oakland—San Francisco access during the following month while the seriously damaged Bay Bridge was repaired. Postquake BART ridership ballooned from about 220,000 to a high of 360,000 during this period, but then gradually subsided. About 10% of these new riders stayed with BART; 6 months after the quake, patronage had returned to its former gradually increasing pattern with a net "earthquake dividend" of 10,000 to 15,000 new one-way trips per weekday. This increase was equal to about 1 year's typical patronage growth. It caused no significant environmental effects around BART stations and trackways, but probably led to a small environmental improvement through reduction of rush-hour auto trips and their air pollution effects.

LONG-RANGE EFFECTS

Apart from unexpected increases in the use of the system, which could add to congestion problems at some stations, the major possible long-term environmental effects of a rapid transit system are those on local and regional land-use patterns. Experience with post-World War II transit improvements in the United States and

Figure 20-8 *Low-impact BART right-of-way in freeway median. (courtesy of Bay Area Transit District)*

Canada indicates that such effects are likely to be small unless encouraged by land-use policy and other factors in addition to the transit system itself.[9] Under such encouragement, the most likely effects are an increase in high-rise office development and possibly some strengthening of retail activities in the central business district, plus some focusing of office and apartment construction at some outlying stations. Such effects are probably limited to intraregional transfers of activity, rather than net new growth in a region.

How much the high-rise building boom in San Francisco was caused by BART may never be empirically established. Melvin Webber judged that it "would have happened anyway, but . . . BART . . . made it happen bigger and quicker."[10] The environmental effects of high-rise development in San Francisco have not been very positive. They have been the subject of a separate study, in which increases in noise levels, traffic generation, the blockage of views, shadowing and wind on downtown streets and open space, and their overpowering scale were cited among the negative impacts.[11]

Several Bay Area cities produced ambitious development plans around local stations prior to BART's opening, incorporating high-rise buildings and multilevel commercial and apartment complexes. Many of these were subsequently opposed by the neighboring residents, whose principal response to BART prior to its opening was one of fear about the effects of such development on neighborhood composition and character.[12] In a study of townhouse developments in one of the Bay Area's suburban counties, Dingemans reported that only "some degree of sub-centering (of townhouse developments around BART) has occurred . . . ," and those were more spread out within a mile radius than within the immediate area of the stations.13 He offered four reasons why more clustering had not happened. First, there were few available building sites and most were too small for the usual 10 acres (40,500 m2) or more required for such developments. Of the stations studied by Dingemans, most clustering had occurred around the one that had large sites available. Second, the construction of large parking lots (up to 1500 cars or 8 acres) has preempted close-in sites. Third, public opposition to townhouses emerged in the early 1970s partly because they had been allowed to locate in scattered sites. "Residents for Density Control," a local ad hoc group, effectively blocked proposals for townhouses in the vicinity of some stations. The fourth and final reason for little clustering was the willingness of the suburban cities to allow commercial centers to locate away from station sites. Part of this was also due to BART's location policies, which emphasized the use of cheaper sites away from existing centers.

Inner-city neighborhoods have also opposed increasing densities around the stations and have sponsored "down zoning."14 Environmental change around many stations is, therefore, almost at a standstill, even though it makes "regional" sense to increase densities in those locations. This may, however, only be a slowing down of the process rather than a permanent halt. Here is a case of conflicts among environmental qualities. Increased densities around stations are seen as decreasing comfort conditions for nearby residents, but they improve pedestrian access, encourage transit use, and can create fine urban environments. The need is for more sensitive and participatory planning for densification, identifying particular development sites, utilizing air rights, improving pedestrian access, and so on, while maintaining some continuity of character.

Some observers have noted that low-density residential development has been strong in the BART suburban corridors around and beyond the terminal stations and have offered this as evidence that BART has actually helped to further sprawl in these corridors.15 Certainly, the rail service's long lines have made the distant suburban areas more attractive for residences of downtown commuters, and the combination of available land, low-density zoning, and large BART parking lots for auto access from such residential areas has encouraged a conventional spread-out form of development. Indeed, it has historically been the case that transportation arteries, whether the original streetcar lines or the later major highways, have had exactly that role.16 More recently, a study of the Metrorail system in Washington, D.C., suggested that station-area development on the suburban fringes of the system was more likely to be commercial than residential and would attract more auto users (from beyond the end of the rail line) than transit users.17 These experiences support the contention that careful land-use planning is needed if the desired results are to be achieved.

TRANSIT MODES OTHER THAN RAPID RAIL

The environmental impacts of other transit modes have not been well-documented, in comparison to detailed studies of rail rapid transit systems such as BART.

rail findings to provide some indicators of how the effects of these other modes compare with those of BART-like rail systems.

Systems of interest in addition to conventional rail rapid transit include commuter rail, light rail, innovative fixed-guideway systems, and regional all-bus operations. Not all of these modes are direct competitors, in that the differences in their service characteristics sometimes lead them to serve quite different markets and purposes. Light rail, for example, is usually not a reasonable substitute for a commuter rail system. Consequently, their environmental impacts should not be interpreted immediately as indications that one system is "better" than another.

COMMUTER RAIL

The environmental impacts of commuter rail systems are likely to be much smaller than even those of rapid rail systems such as BART. Typically, an existing freight rail right-of-way is used, service is infrequent relative to that of rapid rail systems, and suburban station facilities are less obtrusive and their patronage lower in most cases. Construction impacts are likely to be small even if new trackage is laid.

The typical baseline for commuter rail evaluation is an all-highway system. Regional effects on traffic and associated impacts can be estimated quite easily for given patronage levels, as with BART. At a corridor level, effects on parallel freeway traffic and downtown parking can be substantial, although on a regional basis these effects are not substantial except for the largest commuter rail networks. It would appear that other environmental concerns are unlikely to be significant in decisions concerning the inauguration or expansion of commuter rail facilities. Their higher speeds, given the option of express trains, can, however, bring places as far as 60 mi (97 km) from urban centers into commuting range, as has happened in the southern region of London where the commuter rail extensions have resulted in the growth of many small towns, but sprawl has been prevented by green belt controls.

LIGHT RAIL

Light rail systems usually run at moderate speed and on separate at-grade rights-of- way. Attributes of modern light rail systems most relevant to environmental impact include their use of some grade crossings and small, relatively numerous stations or stops. To the degree that these characteristics are rejected in favor of high-speed, mainly grade-separated operation and large, widely spaced stations with parking (as in Edmonton, Canada) impacts will approach those of rapid rail systems. However, with the more standard configuration, impacts should be substantially less because of the lack of concentration of activity. Major concerns are likely to be limited to grade-crossing safety; other impacts, such as noise and visual effects, are less likely to be significant than for rapid rail systems.

Several light rail construction projects have been either undertaken or completed in the United States during the 1980s. These have generally made use of former railroad rights-of-way or freeway medians wherever possible and often resemble full scale rapid transit systems with station parking lots and grade-separated guideways (for example, Sacramento, California). At the same time, some new light rail systems make heavy use of at-grade mixed-traffic trackage either along or crossing arterial streets, with some attendant problems with traffic accidents (for example, San Jose, California). No other significant environmental problems have been widely reported.

INNOVATIVE FIXED-GUIDEWAY SYSTEMS

Innovative fixed-quideway transit can encompass very different types of systems, such as "personal" (very small cabin) systems with relatively extensive guideway networks, "people-mover" and MRT (medium-density rail transit) systems with small-to medium-capacity vehicles, and very high speed, long-distance systems with advanced propulsion/suspension technologies such as magnetic levitation. Only a few examples of the people-mover variety have been built in the United States; although most are in airports and amusement parks, several small systems have been built for circulation in downtown areas such as Miami and Detroit. All these are very small, low-speed, closed- loop systems with small elevated guideways, simple platforms in lieu of stations, and no parking. As such, they are not comparable to full-scale urban transit systems, although their technologies could be used in larger systems.

The impacts of innovative guideway transit systems will vary substantially, depending on specific system characteristics such as those just noted (for example, size, speed, station patronage, and parking). However, the types of impact and their causes identified as important in the BART study can provide useful indications of the key impact concerns for all systems. Many environmental impacts have little to do with guideway technology. For example, suburban station-area concerns focus on overflow parking and other access-related issues. If used in such commute-oriented applications (and at similar levels of patronage), transit systems usually cannot avoid such problems, no matter what technology is used. Likewise, with any transit technology a system's effects on regional air quality will not be substantial unless the system carries a high proportion of the region's trips.

Innovative guideway systems are most likely to have environmental impacts different from those of BART along the guideway itself. BART has proved that heavy-rail, high-speed rail transit systems can be acceptably quiet; but if an innovative system is only slightly noisier, residents within two or perhaps more blocks will probably have reason to complain. Conversely, a system slightly quieter than BART will cause almost no discernible effect on most acoustic environments. Guideway bulk is another example: Some proposed guideway systems may involve either lighter or bulkier guideways than that of BART. Since the bulk or shadowing effect of BART's guideways is not a cause of significant complaint, lighter guideways are unlikely to produce a significant improvement. Even if such systems require slightly less right-of-way, the resulting closeness of the guideway may offset its smaller size. Bulkier guideways, such as those with side walls for guidance of untracked systems, may cause significant shadow and view-blocking problems. These problems are important when narrow rights-of-way are used in residential areas and are of concern for downtown people-mover systems in congested areas.

REGIONAL ALL-BUS SYSTEMS

As already noted, the BART study defined the system's environmental impacts as the differences between the existing situation (with BART) and a hypothetical "no-BART alternative" scenario that relied on a regional all-bus system large enough to carry about the same number of trips. Some significant environmental impact differences between BART and an all-bus system might be those occurring around the BART stations and guideways, where the alternative bus system would have few or no offsetting effects. However, if the regional bus system were to have terminals or if it were to disperse along arterial streets, its impacts could be more widespread than BART'S. Comparative research on the environmental impacts of buses versus automobiles carrying equal numbers of passengers has not been carried out, but buses are known to have substantial negative impacts on residential streets.18 However, bus systems are necessary even with a rail system, to serve shorter trips and the collector-distributor role. The important issue is whether the increase in total bus operations required by the all-bus alternative to serve the longer trip and express functions (otherwise covered by rail transit) would be enough to have significant environmental effects. In the BART study, it was concluded that it would not.

CONCLUSIONS

ENVIRONMENTAL IMPACT ASSESSMENT PROCEDURES

Several observations can be made concerning how the practice of environmental impact analysis changed in the 1980s.19 First, the EIS process became more structured. Guidelines from UMTA and other agencies not only provided instructions on what areas to analyze, but indicated, in some cases, how the analysis should be performed, how to deal with certain possibilities, and criteria for acceptability of certain impacts. Such standardization was helpful both to the applicant and to the UMTA reviewer and facilitated an apples-to-apples comparison among competing requests for limited funding.

Second, the treatment of environmental issues, as in urban planning in general, was as much political as technical. A single controversial environmental issue provided an easy target for those who opposed a system on more subtle grounds. When the methane gas explosion, described earlier, occurred in what would be the path of the Los Angeles Metro Rail, extensive technical studies were conducted to assess the dangers of tunneling through the area. While different experts were found to testify on both sides of the question, the preponderance of evidence, including experience with similar conditions elsewhere, indicated that the risks could be reduced to insignificant levels if proper precautions were taken. Yet opponents of the system (who failed to prevail during the EIS process itself and during a subsequent court challenge to the

December 1983 FEIS) succeeded in blocking the original subway alignment.

Third, participation in the EIS process became more sophisticated on the part of both the applicant and the public. In some cases, it seemed that applicants learned how to fulfill the letter of the law and satisfy the funding agency without always adhering to the spirit of the law. Applicants also learned, however, the importance of the public participation process. They became adept at developing and maintaining lists of key special interest groups and individuals, at forming citizens' advisory panels, and at soliciting public input early and throughout the EIS process.

At the same time, the public clearly learned that its actions can make or break a project. Virtually no agency will back a system for funding that has major local opposition. Public values per se did not seem to change much in the 1980s: the most common concern remained: How will this project affect me—my property and its value, my neighborhood, my quality of life, my mobility? The NIMBY (not in my back yard) syndrome continued at least as strong as ever and perhaps became more forcefully and effectively expressed.

Perceived impacts are just as important as real ones in the eyes of the public. For example, the operating noise of a rail transit system is an issue that, technologically, has been largely solved through advances in vehicle, guideway, and sound barrier construction. Yet there is typically a visceral reaction against the expected noise of a proposed system that no amount of scientific measurements and models can reverse.

The prohibition of tunneling through methane gas areas in Los Angeles necessitated the identification of alternatives. Early efforts focused on keeping roughly the same alignment as before, but changing the grade from subway to aboveground. On the other hand, there was vocal opposition by residents to an aerial or at-grade system. In view of this opposition, it was decided to change alignments altogether and head north to Hollywood and the eastern San Fernando Valley rather than west to Santa Monica. Thus, rail service to the Wilshire corridor, containing the densest development in the region outside of downtown Los Angeles, was postponed indefinitely. Also, construction of the second phase of the system was delayed by several years.

Meanwhile, some of the newly proposed alignments were encountering opposition of their own. In particular, the entertainment industry was galvanized into action by a proposed aerial alignment down Sunset Boulevard in proximity to a number of recording studios and sound stages. Again, extensive studies were conducted and, again, the technical evidence and experience elsewhere seemed to indicate that noise and vibration impacts could be mitigated with appropriate measures. Nevertheless, continued industry opposition resulted not only in altering the alignment slightly, but also in changing the grade at that point from aerial to subway. Other noise-reducing measures had already been agreed to because of nearby residential developments.

A final observation on changes in the practice of environmental impact analysis is that postconstruction environmental assessments such as the BART Impact Study, the Washington, D.C., Metrorail Before-and-After Study, and the Transit Impact Monitoring Program for Atlanta's MARTA rail system are seldom conducted.20 There are several related reasons why postconstruction studies are exceptional. The first is the simple expedient of money. An EIS for a major system can easily cost $1 million. (It is estimated that $3 million was spent on the environmental review process for the Los Angeles Metro Rail). A thorough postconstruction or before-and-after study could cost much more, as did the BART Impact Program. Few agencies can afford such an expense for an impact study, especially one donetoo late to affect the design and construction of the system in question.

Second, many impacts of interest are long term in nature, making their evaluation more problematic. As indicated earlier, construction impacts alone will be phased over several years (even a decade or more for larger projects or systems), operational impacts will not stabilize for several years after that, and land-use impacts will perhaps not reach equilibrium for decades. In a sense, each of the three postconstruction studies mentioned above took place too soon, did not last long enough, or both. It would be unusual indeed to see a meaningful level of resources committed to studying environmental impacts continuously over a period of 20 years or longer, but that is the order of magnitude of time needed to capture the full spectrum of impacts for a major transit system.

The third reason that few postconstruction studies are seen is the relative efficacy of the EIS process itsef. Ideally, the EIS identifies all potentially serious negative impacts, allows for complete airing of all concerns, and develops optimal mitigation measures for reducing or eliminating those impacts. Furthermore, UMTA now requires that these mitigation measures be highlighted in the executive summary of the EIS and writes compliance with those measures into the full funding contract for the project. Therefore, there is less need for an additional study monitoring impacts. On the other hand, it would be a mistake to argue that a postconstruction study is useless. There is still a lot such a study can teach us about how to improve our models of impact prediction and about the effectiveness of certain mitigation strategies.

The environmental impact review process is decidedly a mixed blessing. At its best, it provides the opportunity for crafting a better project (from an environmental standpoint) than would be arrived at otherwise. At its worst, it is either a meaningless formality and a waste of time and money or a tool for obstruction by parties who may not represent the collective best interests of those affected by the project. The challenge here, as in so many other areas of public planning, is to continue to improve the process without unduly impairing its effectiveness.

OBSERVED ENVIRONMENTAL IMPACTS

Overall, our experience to date indicates that the environmental impacts of modern public transit systems are likely to be small in comparison to those of urban freeways. For all types of transit systems, the most important determinant of environmental impacts is the proportion of a region's trips that are captured, because of both their diversion from autos (a local and regional benefit) and their resulting focus on transit stations (with both local benefits and detriments).

Significant regional-scale benefits such as air quality improvement require much larger transit patronage than achieved to date on most existing systems. Similarly, major land-use impacts cannot be anticipated without strong complementary physical, economic, and local public policy factors to support the transit system's potential.21

In contrast to the scarcity of regional influence, transit systems can have substantial localized environmental effects. Even moderate patronage levels can cause noticeable adverse impacts, especially at outlying stations in residential areas. At the higher levels of patronage needed to generate desirable regional benefits, these localized adverse effects could become serious problems. Under such conditions, stations should be located away from sensitive environments such as quiet neighborhoods or be planned to combine with regional centers or arterial streets.

Different transit modes do have significant differences in environmental impact. Transit modes may often be more complementary than substitutable; rapid rail systems serve high volumes and long trips; buses are appropriate for station feeder routes and lower-volume, more dispersed corridors; and light rail systems fit best with intermediate conditions. Thus immediate environmental impacts are not likely to be the dominant factor in selecting among transit modes. Once a transit mode is selected, however, its environmental impacts can be controlled in important ways based on the on the experiences reported in this chapter.

Some perspective on this conclusion may be provided through comparison with other transportation strategies. In particular, major regional benefits such as reduction of energy use and air pollution are much more likely through private ridesharing (car- and vanpooling) arrangements; an increase in average peak-period auto occupancy from 1.2 persons per vehicle to 1.4, which is only about one additional person in every sixth car, would do far more toward attainment of most regional environmental objectives than could a rapid transit system such as BART. Improvements in automobile engine combustion efficiency, use of smaller autos with smaller engines, and a shift to electric-powered vehicles could also have larger effects in achieving benefits of this type.

The distribution of impacts can vary for different transit systems. The more transport flows can be concentrated on major channels (such as with rail transit), the fewer the number of persons that are affected, especially since the rail system's typical level of impact is low. The more dispersed the transit system, as with a regional bus system, the more it approaches the pervasive impact of the automobile. No one has yet calculated, to our knowledge, the relative distributions of impacts of different transit systems. Nevertheless, there are some clues. A Bay Area study of noise, for instance, found that 40% of a randomly selected population complained of local street traffic, whereas those disturbed by freeway noise amounted to only 24%. Bus transit systems that use local streets may, therefore, cause more widespread environmental problems than regional rail systems. At the same time, the concentration of transit and other traffic on arterial streets rather than neighborhood streets and the introduction of quieter and less polluting street transit vehicles may pay even greater environmental dividends.

A major issue outstanding in the evaluation of the environmental impacts of transit options is that of long-term effects on urban form and function. Some transit modes, notably high-capacity fixed-guideway systems, may be instrumental in the achievement of a more land-efficient, multicentered urban configuration with major benefits in internal protection of the surrounding natural environment. Studies indicate that such transit systems may have encouraged progress in this direction. At the same time, provision of rapid transit is but one ingredient, albeit a key one, in a necessary blend of closely related physical and policy inducements if cities are to be restructured to any significant degree. Given such interdependence of causal forces, rapid transit alone cannot be credited with long-range benefits of this nature.

Once a local commitment is made to mobilize such complementary forces to change the course of a city's future development, a new (or extended or improved) fixed-guideway form of public transit must be given serious consideration as an element in the overall strategy. At this point the relative environmental merits of alternative systems must be considered, as outlined in earlier sections. Nonguideway systems appear to be much less likely to contribute to urban growth-focusing objectives than do either conventional or innovative fixed-guideway systems.

Where a guideway form of transit is adopted, the evidence indicates that effective steps can be taken to mitigate adverse guideway impacts. The major approaches include thoughtful location of stations, careful planning of their surrounding development, and the selection of trackway configuration in keeping with the sensitivity of the urban environments to be traversed. This sensitivity is largely determined by factors such as ambient sound levels, local traffic intensity and capacity, right-of-way width, and the presence of residential or similarly sensitive land uses. Other efforts to optimize impact may include rapid construction, high-quality architectural design, transit vehicle sound control, provision of adequate parking, extensive feeder bus service, landscaping, and other compensatory measures. With such efforts, rapid transit's environmental impact need not be a major problem and indeed can offer some significant improvements in the quality and structure of urban environments.

APPENDIX A

Typical Areas of Environmental Analysis

For each of these areas, the *UMTA Guidelines* found in Circular 5620.1 provide criteria for judging whether or not a proposed action will have a significant impact.

1. *Land acquisition and displacements:* including displacements of residences and businesses.
2. *Land use and zoning:* compatibility with surrounding uses and conformance to zoning requirements.
3. *Air quality:* due to changes in auto and/or bus traffic, and especially as sensitive areas such as parks, schools, and hospitals are affected.
4. *Noise:* including noise from fixed transit facilities, diverted traffic, or the operation of transit vehicles.
5. *Water quality:* including impacts on surface bodies of water nearby and storm and sanitary sewers.
6. *Wetlands:* that is, “a lowland covered with shallow and sometimes temporary or intermittent waters," and including impacts on associated wildlife.

7. Flooding: including "flooding of the proposed project site and flooding induced by the proposed project."
8. Navigable waterways and coastal zones: including land near the coast as well as waterways near the proposed project.
9. Ecologically sensitive areas: that is, areas containing "natural features that require protection," such as "woodlands, prairies, marshes, bogs, lakes, streams, scenic areas, landforms and geologica1 formations, and pristine natural areas."
10. *Endangered species:* including flora and fauna.
11. *Traffic and parking:* including traffic generated by the project as well changes in traffic patterns.
12. Energy requirements and potential for conservation: that is, the energy needed to construct and operate the project; and the potential to reduce energy consumption through increased energy efficiency, increased vehicle occupancy, a shift to energy-efficient modes, reduction of demand for vehicular travel, and/or development of more efficient routes or travel patterns.
13. Historic properties and parklands: that is, those properties subject to Section 106 of the National Historic Preservation Act of 1966 (historic sites) and/or Section 4(f) of the Department of Transportation Act of 1966 (parks, recreation areas, wildlife refuges, and historic sites).
14. *Construction:* impacts to be analyzed include noise, disruption of utilities, disposal of debris and spoil, water quality and runoff, access and distribution of traffic, air quality and dust control, safety and security, and disruption of businesses.
15. *Aesthetics:* visual impacts of the proposed action.
16. Community disruption: the potential for isolation, disruption, or displacement of physical sectors or activities of the community.
17. Safety and security: measures taken to prevent accidents or criminal activity associated with the project.
18. *Secondary development:* land-use changes stimulated by the proximity of a transit facility or service.
19. Consistency with local plans: including comprehensive or general plans, specific plans, and transportation plans for the area affected by the project.

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20 See examples in the Further Reading.

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EXERCISES

20-1 Define and relate the following terms to build a conceptual description of the environmental impact process: environment, emission, impact, perception, evaluation, and response.

20-2 What two things must be compared to be able to measure impacts? How precisely are these things known, and why? In this context, what is an impact?

20-3 Using the UMTA impact categories, describe five potentially positive and five potentially negative environmental impacts of transit systems.

20-4 Give specific examples of the following: direct and indirect impacts; internal and external impacts; magnifying and mitigating features; planning, construction, start-up, stable-operation, and long-term impacts.

20-5 List four forms of adaptation or response to transit system impacts together with specific examples of each.

20-6 What is the difference between an EIS, an EA, and an EIR? What is a categorical exclusion? What is a FONSI?

20-7 Using BART or another situation as an example, explain why selection of the "no- build" or baseline alternative is not always straightforward.

20-8 What were some of the construction impacts experienced with BART? How and to what extent can these be mitigated in future system construction?

20-9 What are the major impacts of BART under stable, full-scale operations? How might these impacts be mitigated in future systems? What impacts appear to be relatively minor?

20-10 Briefly describe the pros and cons of the environmental impact review process.

20-11 Explain some ways—both desirable and undesirable—in which a major urban rail system might affect land use. How does transit interact with other factors to create land-use impacts?