NCHRP

REPORT 466

NATIONAL
COOPERATIVE
HIGHWAY
RESEARCH
PROGRAM

Desk Reference for Estimating the Indirect Effects of Proposed Transportation Projects

TRANSPORTATION RESEARCH BOARD

NATIONAL RESEARCH COUNCIL

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Desk Reference for Estimating the Indirect Effects of Proposed Transportation Projects

THE LOUIS BERGER GROUP, INC.
East Orange, NJ

SUBJECT AREAS
Planning and Administration • Energy and Environment • Transportation Law • Highway and Facility Design
Aviation • Public Transit • Rail • Freight Transportation • Marine Transportation

Research Sponsored by the American Association of State Highway and Transportation Officials
in Cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD — NATIONAL RESEARCH COUNCIL

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

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The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration, U.S. Department of Transportation.

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FOREWORD

By Staff
Transportation Research Board

This report includes the results of research carried out under NCHRP Project 25-10(02), "Continuation: Estimating the Indirect Effects of Proposed Transportation Projects." Both the desk reference and its accompanying slide presentation contain guidance and a framework for practitioners in defining "indirect effects" of proposed transportation projects, identifying tools for estimating these effects, and analyzing these effects. The report should be of interest to state departments of transportation, metropolitan planning organizations, transit agencies, and other transportation project sponsors. It should also prove to be a valuable resource for transportation planners and engineers, environmental practitioners, and others responsible for project development and environmental impact analysis.

Transportation projects have both direct and indirect effects on the environments in which they are located. Federal environmental policy, as embodied in the National Environmental Policy Act (NEPA) requires the assessment and disclosure of reasonably foreseeable effects of transportation projects as part of the environmental impact assessment process. As a result, procedures have been established to identify and estimate many of the direct effects of projects. However, the indirect effects are more difficult to identify and assess. These indirect effects have repercussions on social and economic conditions, natural resources, cultural/historical resources, accessibility, and many other conditions. States and other transportation project sponsors have expressed a need for guidance in identifying and estimating the indirect effects of proposed projects. This information is needed so that projects can be designed to reduce their adverse impacts, as well as to maintain project development progress through the environmental impact assessment and decision-making processes.

Research carried out under NCHRP Project 25-10, "Estimating the Indirect Effects of Proposed Transportation Projects," identified various types of indirect effects and produced a framework with supporting analytical methods for transportation agencies to estimate the indirect effects of proposed transportation projects in preparing environmental impact statements and related studies. This research has been published as *NCHRP Report 403: Guidance for Estimating the Indirect Effects of Proposed Transportation Projects* (hereafter referred to as the *Guidance*).

Transportation agencies continue to remain keenly interested in the issue of how to appropriately approach indirect effects estimation. Auxiliary materials to train practitioners in the use of the *Guidance* need to be available in formats that will facilitate its use.

The objectives of the continuation were (1) to update and refine the *Guidance* to reflect developments on the issue since publication of the contractor's final report for Project 25-10 and to provide new or improved items for a practitioner's toolbox; (2) to conduct historical case study analyses to provide an improved retrospective of indirect effects for application in estimation approaches; and (3) to develop training materials for practitioners in use of the *Guidance.*

The Louis Berger Group, Inc., of East Orange, New Jersey provided the research team for this project and prepared the desk reference and slides. These products reflect information obtained from a broad range of sources, including a survey of more than 350 federal and state transportation and environmental agencies, academic institutions, and other organizations having interest and expertise in transportation project planning and development. From this data collection, the authors have provided a thorough synthesis of agency regulation, case law, published literature, environmental impact statement content, and practitioner experience and perspective leading to a typology of "indirect effects." These products also include a framework for identifying and analyzing indirect effects of proposed transportation projects in order to provide planners and practitioners the ability to integrate indirect effects assessment into ongoing evaluation processes. Finally, the authors have identified appropriate tools and techniques for discerning which of the indirect effects of a proposed transportation project warrant detailed analysis and for carrying out those analyses, as well as a course curriculum for teaching effective methods of applying these techniques. The slides are published in PDF format as NCHRP Web Document 43. Web documents are available at: www4.trb.org/trb/crp.nsf.

CONTENTS

AUTHOR ACKNOWLEDGMENTS

The research reported herein was performed under NCHRP Project 25-10 (2) by The Louis Berger Group, Inc. (Berger), the contractor for this study. Lawrence Pesesky, Vice President for Transportation Planning at Berger, was the principal investigator. The other authors of this report, all employees or former employees of Berger, were Albert Racciatti, Dane Ismart, Kevin Twine, Matthew Ireland, Julie Zarate-Watson, and Rachael Conaty. Editing of the contractor's report was performed by Alex Rosenzweig, and assistance with graphics and illustrations was provided by Patricia Allen.

COURSE MODULE **1**

INTRODUCTION TO INDIRECT EFFECTS ANALYSIS

OVERVIEW

Transportation projects have a wide range of effects on the environments in which they are located. Some of these effects are directly attributable to aspects of the project's design or function. These direct effects are often the subject of considerable scrutiny as a project is planned, and efforts are made to avoid, minimize, or reduce those effects that are considered adverse in nature and to enhance those effects that are considered beneficial. Other effects on the natural or social aspects of the human environment are more indirectly attributable to a transportation project. These indirect effects are often not as readily apparent because they are more removed from the transportation improvement in time or space.

Federal environmental policy, as embodied in the National Environmental Policy Act (NEPA) requires the assessment and disclosure of all reasonably foreseeable effects of transportation projects as part of the environmental impact assessment process. As a result, procedures have been established to identify and estimate many of the direct effects of projects. Indirect effects have received less attention, however, because of the inherent difficulties in their identification and assessment. Indirect effects are a source of significant impacts on social and economic conditions, natural resources, cultural/historical resources, accessibility, and many other conditions. States and other transportation project sponsors have expressed a need for guidance in identifying and estimating the indirect effects of proposed projects. This information is needed so that projects can be designed to reduce their adverse impacts, as well as to maintain project development progress through the environmental impact assessment and decision-making processes.

In response to the need for guidance on indirect effects, the NCHRP initiated Project 25-10 (1), "Guidance for Estimating the Indirect Effects of Proposed Transportation Projects." The *Guidance* was published in 1998 as *NCHRP Report 403.* This manual, also prepared through NCHRP under Project 25-10 (2), is designed as an update and companion to that guidance document and a learning tool for practitioners. The manual is organized around the eight-step framework for estimating indirect effects that was presented in *NCHRP Report 403.* Steps in the framework are outlined below.

Step 1—Scoping: The basic approach, effort required, and geographical boundaries of the study are determined in this step (see Course Module 3).

Step 2—Identify the Study Area's Direction and Goals: In this step, information regarding the study area is compiled with the goal of defining the context for assessment (see Course Module 4).

Step 3—Inventory the Study Area's Notable Features: Additional data on environmental features are gathered and synthesized during this step. The goal is to identify specific environmental issues by which to assess the project (see Course Module 5).

Step 4—Identify Impact-Causing Activities of Proposed Action & Alternatives: The component activities of each project alternative are fully described during this step (see Course Module 6).

Step 5—Identify Potentially Significant Indirect Effects for Analysis: Indirect effects associated with project activities and alternatives are cataloged, and potentially significant effects meriting further analysis are identified (see Course Module 7).

Step 6—Analyze Indirect Effects: Qualitative and quantitative techniques are employed to estimate the magnitude of the potentially significant effects identified in Step 5 and describe future conditions with and without the proposed transportation improvement (see Course Module 8).

Step 7—Evaluate Analysis Results: The uncertainty of the results of the indirect effects analysis is evaluated for its ramification on the overall assessment (see Course Module 9).

Step 8—Assess Consequences and Develop Mitigation: In this step, the consequences of indirect effects are evaluated in the context of the full range of project effects. Strategies to avoid or lessen any effects found to be unacceptable are developed. Effects are reevaluated in the context of those mitigation strategies (see Course Module 10).

In addition to the eight steps in the framework, this manual will also discuss other important issues relating to the topic, including the following:

- Definitions of important terms (see below);
- Legal and regulatory context for indirect effects analysis (see below);
- Literature on indirect effects analysis (see below);
- Summaries of state guidance documents (see below);
- Review of case law relating to indirect effects (see Course Module 2); and
- Case studies of techniques employed in recent project evaluations, which are available in *NCHRP Report 403*, Appendix E (Case Studies).

The goal of this course manual is to provide step-by-step guidance on indirect effects analysis to practitioners in agencies responsible for the evaluation of environmental impacts of transportation projects. The manual provides an overview of methods appropriate for each step, resources for further information regarding techniques, and a discussion of the considerations involved in choosing methods and structuring the research approach. By the conclusion of the course, it is expected that the student will have knowledge of the following:

- Definitions of important terms and concepts including direct, indirect, and cumulative effects; the three main types of indirect effects; the terms "significant" and "reasonably foreseeable;" and other important terms.
- The legal and regulatory basis for indirect effects analysis and the recent opinions issued by the courts.
- Literature on indirect effects analysis and recent guidance documents produced.
- Techniques in scoping for indirect effects analysis and choosing a study area.
- Data sources and techniques for compiling an inventory of goals, notable features, and impact-causing activities of the project.
- Methods for identifying potentially significant indirect effects meriting further analysis.
- Qualitative and quantitative methods for forecasting project-influenced effects, ways in which techniques may be combined based on project circumstances, and techniques for evaluating and dealing with the uncertainty of forecasts.
- The issues involved in assessing the consequences of significant effects and the development of strategies to address unacceptable effects.

IMPORTANT TERMINOLOGY

Direct Effects—The Council on Environmental Quality (CEQ) regulations state that direct effects are "caused by the action and occur at the same time and place" (40 CFR 1508.8). Commentators have also noted that these on-site effects directly linked to the project action are highly predictable. The following are examples of direct effects:

Project Action	*Direct Effect*
Right-of-way acquisition	Displacement of local businesses
New highway	Severing of direct access between residential area and school
Lanes added	Speed increased and/or traffic moved closer to residences Unacceptable noise in local residences

A summary of the distinction between direct, indirect, and cumulative effects can be found in Figure 1-1.

Indirect Effects—According to the CEQ definition, indirect effects are "caused by the action and occur later in time or farther removed in distance, but are still reasonably foreseeable" (40 CFR 1508.8).

Indirect effects "may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8).

The CEQ definitions and a review of the literature suggest three broad categories of indirect effects:

1. Alteration of the behavior and functioning of the affected environment caused by project encroachment (physical, chemical, biological) on the environment;
2. Project-influenced development effects (i.e., the land use effect); and
3. Effects related to project-influenced development effects (i.e., effects of the change in land use on the human and natural environment).

Indirect effects can be linked to direct effects in a causal chain. The chain can be extended as indirect effects produce further consequences. Examples of indirect effects:

Project Action	*Direct Effect*	*Indirect Effect*
Bypass Highway	Improved Access	Farmland converted to residential use New residences produce new labor force attracting new businesses
New Light Rail	Improved Access	New businesses open producing jobs/taxes Traditional businesses/ residents priced out
New Highway	Improved Access	Development alters character of historic area Visitors increase to historic area

Examples of indirect effects given by various agencies in their documentation can be found in Figure 1-2. Other examples of indirect effects are listed in Figure 1-3.

Type of Effect	Direct	Indirect	Cumulative
Nature of Effect	Typical/ Inevitable/ Predictable	Reasonably Foreseeable/ Probable	Reasonably Foreseeable/ Probable
Cause of Effect	Project	Project's Direct and Indirect Effects	Project's Direct and Indirect Effects and Effects of Other Activities
Timing of Effect	Project Construction and Implementation	At Some Future Time than Direct Effect	At Time of Project Construction or in the Future
Location of Effect	At the Project Location	Within Boundaries of Systems Affected by the Project	Within Boundaries of Systems Affected by the Project

Figure 1-1. Distinctions between types of effects.

Cumulative Impacts—Also addressed by CEQ (40 CFR 1508.7), cumulative impacts are defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions."

The goal of cumulative effects analysis is to inform decisionmakers evaluating projects individually as to the changes in characteristics and trends of an area from the combined effects of incremental actions.

Guidance released by the EPA and U.S. DOT confirm that "other actions" include not only actions of the sponsoring agency related or unrelated to the subject project, but also actions by other government agencies, private citizens, and corporations.

In practice, analysis of cumulative effects has been incorporated with the assessment of indirect effects because many indirect effects, including induced development effects, fall within the definition of cumulative impacts.

EPA states:

> While impacts can be differentiated by direct, indirect, and cumulative, the concept of cumulative impacts takes into account all disturbances since cumulative impacts result in the compounding of the effects of all actions over time. Thus the cumulative impacts of an action can be viewed as the total effects on a resource, ecosystem, or human community of that action and all other activities affecting that resource no matter what entity (federal, non-federal, or private) is taking the actions.

Assessment of cumulative impacts often involves integration of other foreseeable actions into all of the alternatives considered, including, if applicable, the No Action alternatives. The following are examples of cumulative effects:

Project Action		*Other Action*		*Cumulative Effect*
New Highway	+	Expanded Airport	=	industrial development, sewer/water required
New Light Rail	+	Zoning Changes	=	tall buildings cast shadow on parkland
New Interchange	+	Proposed Shopping Mall	=	increased weekend traffic on local roads
New Highway	+	Suburban Development	=	increased traffic and highway congestion

Secondary Effects—In most instances, the terms "secondary effects" and "indirect effects" are used interchangeably. Some commentators (Vlachos, 1976; Hamilton, 1988; and Schaenman and Muller, 1974) differentiate secondary from indirect effects by equating secondary effects with induced development and related effects.

Reasonably Foreseeable—Following is the definition for "likely" and "reasonably foreseeable" adopted by many courts in indirect effects cases:

> The terms "likely" and "reasonably foreseeable" are properly interpreted as meaning that the impact is sufficiently likely to occur that a person of ordinary prudence would take it into account in making a decision. (*Sierra Club v. Marsh,* 976 F.2d (1st Cir. 1992))

According to CEQ guidance (*Forty Most Asked Questions Concerning CEQ's NEPA Regulations,* 46 FR 18031, 1981) reasonably foreseeable events although uncertain, must also be probable.

Effects that can be classified as possible but not as probable may be excluded from consideration.

Agency	Source Document	Example
Federal Highway Administration (FHWA)	Position Paper: *Secondary and Cumulative Impact Assessment in the Highway Project Development Process*, FHWA, April 1992.	Changes in land use, water quality, economic vitality and population density; negative impacts on endangered species; effects on the ability of existing environmental protection measures to absorb an increased load (e.g.. water treatment plant must work harder because of more pollutants due to project). *secondary and induced*
	Guidance for Preparing and Processing Environmental and Section 4(f) Documents, T 6640.8A, 1987.	Any land use activities that can be considered secondary, including social, economic and environmental. *secondary*
Federal Transit Administration (FTA)	*Procedures and Technical Methods for Transit Project Planning*, September 1986.	Increased congestion resulting from development; impact on parking and highway traffic; increased demand for housing near a rail station could have the effect of raising rents and driving out poorer tenants; availability of commercial space could be affected by changes in residence patterns; impaired access to buildings, parks, transit delays, etc., all due to construction. *secondary development*
	U.S. Department of Transportation (U.S. DOT), Urban Mass Transit Administration Circular, UMTA C 5620.1, *Guidelines for Preparing Environmental Assessments*, October 16, 1979.	Impacts of secondary development on community development patterns; changes in local infrastructure; changes in local socioeconomic characteristics. *secondary development*
Federal Aviation Administration (FAA)	*Order 5050.4A Airport Environmental Handbook*, U.S. DOT, FAA, October 8, 1985.	Shifts in patterns of population movement and growth, public service demands, and changes in business and economic activity due to airport development; regional growth and development, spin-off jobs, induced impacts on natural environment. *indirect*
	Tips for Airport Sponsors and Their Consultants, FAA, Southwest Region, 1993.	Population increases, public service demands (fire and police), and changes in economic activity due to operation of airport. *indirect*
	Estimating the Regional Economic Significance of Airports, U.S. DOT, FAA, pp. 92-96, September 1992.	Off-site economic activities attributable to the airport, such as travel agency services, hotels, restaurants, retail establishments. *indirect*
U.S. Fish and Wildlife Service (USFWS)	USFWS, *NEPA Handbook*, Release 30-4, September 1983.	Vegetation management causing a change in plant species which can result in a change in grazing patterns and animal population; changes in native fish stock due to artificial fish stocking which increases food demand (by predators) in that stream. *final ultimate change*
U.S. Environmental Protection Agency (U.S. EPA)	U.S. EPA Dredge or Fill Regulations, 404(b)(1) Guidelines, Section 230.21(b).	For an ecosystem: fluctuating water levels in an impoundment and downstream associated with the operation of a dam, septic tank leaking and surface runoff from residential or commercial developments on fill, and leachate and runoff from a sanitary landfill located in waters of the United States. *secondary*

Figure 1-2. Examples of indirect or secondary effects by various agencies.

Probability also helps distinguish indirect effects from direct effects: direct effects are often inevitable while indirect effects are merely probable.

Induced Growth—Changes in the intensity of the use to which land is put that are caused by the action/project. For transportation projects, induced growth is attributed to changes in accessibility caused by the project, which influences where development occurs.

Accessibility—The ease of movement between places. As movement becomes less costly—either in terms of money or time—between any two places, accessibility increases. The propensity for interaction between any two places increases as the cost of movement between them decreases. Accessibility is also defined as the attractiveness of a place as an origin (how easy it is to get *from* there to all other destinations) and as a destination (how easy it is to get *to* there from all other destinations). Consequently, the structure and capacity of the transportation network affect the level of accessibility within a given area. The accessibility of places has a major impact upon their land values (and hence the use to which the land is put), and the location of a place within the transportation network determines its accessibility.

Major Activity Center—A geographic area characterized by a large transient population and heavy traffic volumes and densities; for example, central business district (CBD), major air terminal, large university, large shopping center, industrial park, or sports arena.

PROJECT ACTION	DIRECT EFFECT	INDIRECT EFFECT	INDIRECT EFFECT	INDIRECT EFFECT	INDIRECT EFFECT
Socioeconomics and Land Use					
Bridge to undeveloped area	-> Improved access	-> Residential development			
Highway extension	-> Improved access	-> Land use development	-> Floodplain encroachment		
Harbor improvements	-> Improved movement of goods	-> Industrial development near waterfront	-> Visual impact on shoreline		
New highway	-> Improved access	-> Land use development	-> Pre-emption of farmlands		
By-pass highway	-> Improved access	-> Development of commercial land uses on by-pass	-> Increased tax revenues from commercial ratables		
Construction of new highway	-> In-migrant Construction work force	-> Income to construction workers spent locally	-> Local businesses hire new employees	-> Population increase because of new employees moving into area	-> Increased demand for community facilities
New highway	-> Improved access to vacant land suitable for industrial development	-> Development of new businesses and industries on these industrial lands	-> Regional economic growth (increased income, employment & earnings)		
New highway bypass around congested downtown area	-> Improved access to vacant suburban land suitable for commercial development	-> New shopping malls and highway-oriented businesses locate on this land	-> Business declines in older downtown area which was by-passed	-> Downtown area deteriorates	
Adopt 'No Action' alternative instead of highway bypass around congested downtown area	-> Additional parking areas and bus routes provided to serve downtown businesses	-> Downtown businesses upgraded	-> More business activity and shopping takes place in downtown	-> Public improvements such as malls, sheltered bus stops, etc	
Adopt `No Action' alternative instead of highway bypass around congested downtown area	-> Businessmen and planners can not agree on downtown renewal program	-> Downtown business slows and the area deteriorates	-> The city suffers declines in population, income, employment		
New general aviation airport	-> Aviation-related businesses locate on or near new airport	-> New businesses hire and provide income for local workers	-> Regional economy improves		
Addition of new runway at metropolitan area airport	-> Construction materials purchased in region of airport	-> Local suppliers use increased income for productivity improvements	-> Productivity improvements increase competitiveness of local suppliers	-> Improved competitive position of local suppliers leads to increased employment	-> Regional economic growth results from new employment and income
Water Quality					
Highway extension	-> Improved access	-> Land use development	-> Increased non-point source water pollution	-> Decline in surface water quality	-> Health problems
Highway extension	-> Improved access	-> Land use development	-> Increased non-point source water pollution	-> Contaminants enter water supply aquifer	-> Contamination of groundwater
Wetlands					
New highway	-> Improved access	-> Land use development	-> Many small wetlands eliminated during development	-> Significant aggregate loss of wetlands due to development	
New highway	-> Alteration of surface water drainage patterns	-> Elimination or degradation of downstream wetlands			

Figure 1-3. Examples of indirect effects. (*Continued on next page*).

Ecology					
New commuter rail line	-> Removal of vegetation and habitat	-> Fragmentation of large habitat area	-> Elimination of species which require this large habitat		
New highway on barrier island	-> Migration of dunes places sand on highway, interrupting traffic	-> Structures built to keep sand off highways	-> Migration pattern of dunes altered	-> Impacts to sensitive barrier island habitat	
New highway in coastal area	-> Culverts built over numerous small streams	-> Interruptions to migration patterns of anadromous fish	-> Juvenile anadromous fish killed in fresh waters	-> Decline in numbers of adult anadromous fish in salt water	-> Decline of commercial fishery for anadromous fish
Air Quality					
New highway	-> Improved access	-> Development of new suburban shopping center and associated commercial activities	-> Creation of air quality contamination `hot spot' exceeding standards	-> Reduction in available increment for future highway projects	
Noise					
New or expanded major international airport	-> New access roads and parking areas required to handle increased passenger load	-> Additional vehicular traffic on these roads produces noise above standards	-> Nearby residential property values are lowered		
Cultural Resources					
New rail mass transit project	-> Improved access for employees to station areas	-> Development of office parks in the vicinity of stations	-> Historic buildings are removed to make way for offices		
New Interstate highway interchange near older city	-> Improved access to nearby rural area	-> Development of land uses in vicinity of interchange	-> Significant alteration of view from historic farm property		
Other					
Highway extension	-> Improved access to undeveloped areas near a city	-> New land use development encounters hazardous waste sites			
New highway	-> Improved access	-> Land use development	-> Increased traffic on local roads and highway	-> Reduced access due to traffic congestion on local roads and highway	
New highway	-> Improvement of traffic flow, stabilization of vehicular speeds	-> Reduced fuel usage for vehicles using new highway	-> Reduced utilization of fossil fuels		

Figure 1-3. (Continued).

SUMMARY OF IMPORTANT LITERATURE ON INDIRECT EFFECTS

The seminal piece on indirect effects of proposed highway projects is a 1976 study conducted by Vlachos for the U.S. DOT. In the study, Vlachos referred to the distinction between primary or direct effects and secondary or indirect effects:

> [D]irect effects are those which result from actual physical construction of the facility, and may be short- or long-term in duration. Indirect effects, on the other hand, are those which are not readily apparent, but are generated by the construction, maintenance or use of the facility.
>
> [S]econdary impacts of highway improvements can be seen as expanding rings of chain reactions, of "ripple effects" extending outward to ever-increasing, but less severe cycles of interrelated consequences. (pp. 5, 22)

He also noted that:

> [S]econdary effects are seen as derivative of primary, being either induced by or stemming from primary. Secondary

> impacts are related more to primary impacts than to the project itself; they are in a sense indirect possible consequences triggered by the construction or sustained use of a highway project but not in themselves "necessary" to the project. (p. 22)

According to Vlachos, a key difference between secondary effects and direct effects is that secondary effects are "possible consequences" of a project, whereas direct effects are a "necessary" or highly predictable consequence of a project. The author further states that primary effects are often just the "tip of the iceberg," and it is the secondary impacts which, over the long term, far outweigh the importance of the direct impact. Vlachos' characteristics of indirect and secondary effects are presented in Figure 1-4. What differentiates Vlachos' interpretation of secondary effects from the CEQ definition of indirect effects is his emphasis on the effects being part of an interactive system, in which the effects generated may work to reinforce one another (p. 3–6).

Vlachos is consistent with the CEQ in defining indirect effects as happening later than direct effects. In addressing the distance specification of the CEQ regulation, Vlachos says that defining distance issues for indirect effects is complex, as the boundaries for political, socioeconomic, and physical indirect effects from the same project will differ.

Hamilton (1988) defines direct effects as those resulting from the construction and operation of the roads (p. 5). Under this definition, the use of the highways also contributes to the direct effect. In his example of direct effects, water pollution would be a direct effect and include impacts from the construction and maintenance of the road, public use of the road, and surface water runoff. This definition, when compared to the CEQ definition, does not specify the timing of the impact or the distance within which the impact must occur to be considered a direct effect.

Indirect effects, in Hamilton's interpretation, are those caused by the acquisition, storage and transportation of materials used in the construction and operation of the highway system, such as the environmental degradation from strip mining for paving materials (e.g., sand, gravel, and limestone). This definition is expansive in comparison to the CEQ definition of indirect effects. The lack of timing or distance specificity incorporates impacts to land, as in the instance of strip mining, possibly thousands of miles from the road alignment. It should be noted that Hamilton's paper discussed effects from the interstate highway system as a whole, not project-specific effects.

Hamilton defines induced effects as impacts resulting from accelerated activities caused by the operation and use of the interstate highway system, for example, the growth of strip developments and their subsequent impact on urban form. The examples given for this interpretation of induced effects include the disposal of cars at the end of their life cycle, the use of petroleum necessary to power cars, and the subsequent environmental impacts of petroleum mining and processing. Hamilton's definition is based on the premise that road improvements will encourage consumption of automobiles over the long term as a favored form of transport.

Note that "induced" impacts is not a term defined by the CEQ. Induced changes to growth, land use and ecosystems are used by the CEQ to describe indirect effects. The language of the CEQ definition suggests that indirect effects are induced changes caused by a project and are not separate and distinct impacts as delineated by Hamilton. Although the CEQ definition for "cumulative" impacts uses the defining term "incremental" impact, Hamilton's interpretation of induced effect is closer to the "cumulative" definition than to an "indirect" effect.

Beale (1993) cites the CEQ definition and writes that both direct effects and indirect effects of a project "are caused by the action." Direct effects "occur at the same time and place," while indirect effects "are later in time or farther removed in distance, but are still reasonably foreseeable." The time-distance parameters in Beale's definition are consistent with

Effect	Characteristic	Definition
INDIRECT	Traceability	direct-indirect
	Order	first-higher
	Space	immediate-extended; local-regional-national
	Timeframe	short-term; long-term
SECONDARY	Scope	proportion of people/things affected, as well as extent (local-widespread) of indirect effects
	Intensity	significance of potential losses/benefits and importance or extensiveness of secondary impacts
	Duration	time required to restore base to present conditions, or achievement of new equilibrium, as well as time span of occurrence (transient vs. persistent and simultaneous vs. delayed)

Figure 1-4. Characteristics of indirect and secondary effects (source: Vlachos, pp. 5–22).

those of the CEQ. Beale's interpretation that these effects are "beyond the boundaries of their immediate jurisdiction" is similar with the CEQ's "farther removed in distance" specification. Where he departs from the letter of the CEQ is in referring to secondary impacts synonymously with indirect effects (p. 4).

Beale deviates from the CEQ in his interpretation of cumulative effects. He defines them as "all effects, including indirect effects, that are induced by the project or exogenous factors. . . . Indirect impacts are induced by a project. Other cumulative impacts are largely independent of a project" (p. 4). Beale argues that the two effects are linked and that an assessment of cumulative effects must be done to properly assess indirect effects. The CEQ guidelines are silent on this issue. However, the CEQ does define cumulative effects in a different section from indirect effects.

Like Vlachos, Beale perceives indirect effects to be a consequence of the project as well as of the direct effect. Moreover, similar to Vlachos, he writes that, while direct effects are highly predictable, indirect effects are "reasonably foreseeable." Figure 1-5 summarizes his interpretations of direct, indirect and cumulative effects.

In *Measuring Impacts of Land Development* (Schaenman and Muller, 1974), the term "spill-over effect" is used interchangeably with "indirect effect." This study is part of series of research conducted by the Land Use Center of the Urban Institute in the 1970s assessing the impacts of land development. The authors explain "spill-over effects" as those effects that "have significant environmental and economic effects beyond the boundaries of their immediate jurisdiction. Examples are water pollutants dispersed through a drainage network, or air pollutants emitted into an air shed" (p. 26).

This study states that secondary effects are those that are induced by an action. The authors give the example of a new development that may act as a catalyst for economic activity which may prompt regional immigration. These descriptions of spill-over effects and secondary effects are consistent with the CEQ definition of indirect effect. The authors also refer to secondary effects as "ripple" effects. No time specificity is made for either spill-over or secondary effects.

In *Transportation Decision-Making: A Guide to Social and Environmental Considerations,* Marvin Manheim (1975) defines indirect effects as those effects "that have ramifications beyond their primary consequences" (p. 65). This definition emphasizes the causal chain between direct effects and indirect effects but does not go further to include a time-distance parameter consistent with the CEQ or that the effect be "reasonably foreseeable." The term indirect effects is again used interchangeably with secondary effects.

The common denominator of the definitions found in published literature seems to be that non-direct (i.e., indirect, secondary, spill-over and ripple) effects are effects on a natural resource, socioeconomic and/or land use system that are a result of the project and/or a consequence of the direct effects.

A close look at interpretations of indirect effects developed before the CEQ definition shows no consensus on any of the CEQ definitional elements—location of impact, timing of impact, predictability of impact, and cause of impact. The definitions developed after 1978, those constructed by Hamilton and Beale, show more cohesion. Both authors agree that indirect effects are effects that are "removed in distance" from the project. However, apart from that point, the definitions diverge on the critical element of what causes the indirect effect. Hamilton believes that it is the use of materials in building the road that is the cause of indirect effects, while Beale says it is the highway project and the direct effects of that project that prompt indirect effects.

Figures 1-6 and 1-7 summarize the different interpretations of indirect effects that have developed before and after the CEQ regulations. Recommendations in the literature regard-

Attribute	Direct Impacts	Indirect Impacts	Cumulative Impacts
Location of Impact	Same Place	Removed in Distance	Removed in Distance
Timing of Impact	Same Time	Later	Later
Predictability of Impact	Highly Predictable	Reasonably Foreseeable	Reasonably Foreseeable
Cause of Impact	Highway Project	Highway Project & Effects of Induced Intermediate Actions	Highway Project & Effects of Induced Intermediate Actions & Other Past, Present, & Reasonably Foreseeable Future Actions

Figure 1-5. Time-distance differentiation of various impact categories (source: Beale, p. 5).

Source	Direct Effects	Indirect Effects	Secondary or Induced Effects	Examples of Effects
CEQ (40 CFR 1508.7 and 1508.8), 1978	Effects which are caused by the action and occur at the same time and place.	Effects that are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable.		Induced effect: Induced changes in land use, population density, or growth rate.
Vlachos, 1976	The immediate or first-order effects or impacts of a given activity.		Secondary effect - Derivative of primary effect, being either induced or stemming from the primary effect.	Direct effect: Influx of construction workers, alterations in land use patterns. Secondary effect: Potential for population growth, potential for sprawl and haphazard development.
Hamilton, 1988	The direct result of the construction and operation of roads. Use of the roads by cars is also a direct impact.	Impacts caused by the storage, acquisition, and maintenance of materials used to build and maintain the highway.	Induced effect - Effect resulting from accelerated activities caused by the interstate highway system.	Direct impact: Visual, noise level increase, air pollution. Indirect impact: Litter and other solid wastes, strip mines. Induced impact: Strip development, auto manufacture.
Beale, 1993	Usually occur within an alignment and can be more widespread or delayed.	Effects caused by the action later in time than direct effect but still reasonably foreseeable.		Incorporates CEQ example for indirect effect by reference.
Schaenman and Muller, 1974		Significant environmental and economic effects beyond the boundaries of the project (spill-over effects).	Secondary effect - Induced effect from a project/development (ripple effect).	Spill-over effect: Greater-than-local development impact such as water and air pollution. Secondary effect: Additional construction from increasing residential and commercial development.
Manheim, et al., 1975		Impacts that have ramifications beyond their primary consequences.		Impact: Changes in activity distribution pattern, travel demand, ecological relationships, and neighborhood character. Indirect: Land value and land use changes.

Figure 1-6. Definitions and examples for direct and non-direct impacts by source.

	pre-CEQ				post-CEQ	
	Schaenman and Muller, 1974	**Manheim, 1975**	**Vlachos, 1976**	**CEQ, 1978**	**Hamilton, 1988**	**Beale, 1993**
Term Used	Spill-over effect and ripple effect		Secondary effect			
Location of Impact	Removed in distance	(No mention)	Boundaries vary for political, physical and socioeconomic effects	Removed in distance	Removed in distance	Removed in distance
Timing of Impact	(No mention)	(No mention)	Later	Later	Present and later	Later
Predictability of Impact	(No mention)	(No mention)	(No mention)	Reasonably foreseeable	(No mention)	Reasonably foreseeable
Cause of Impact	Induced by an action	Caused by the direct effects	Highway project and primary impacts	Highway project	Materials used in highway project	Highway project and effects induced by intermediate action

Figure 1-7. Definitions of indirect effects compared with CEQ.

ing methods and analysis techniques have been incorporated in Modules 3 through 10.

STATUTORY AND REGULATORY CONTEXT FOR INDIRECT EFFECTS

NEPA Process and Implementing Regulation

The federal statute most relevant to the assessment of indirect effects is the National Environmental Policy Act (NEPA) of 1970, as amended. While NEPA does not specifically refer to indirect effects, it contains two sections that are related to indirect effects as a concern for federal projects. First, in Section 101(b), NEPA makes it the responsibility of the federal government to:

> assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings . . . attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences . . . [and] preserve important historic, cultural, and natural aspects of our national heritage. . . . (42 USC 4331 Section 101(b))

In addition, it states that:

> the Federal Government shall include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on the environmental impact of the proposed action [and] any adverse environmental effects which cannot be avoided should the proposal be implemented. (42 USC 4332 Section 102(c))

The meaning of these sections was clarified when the (CEQ) issued its NEPA regulation in 1978, as part of its mission to provide assistance to federal agencies on implementing NEPA. In the terminology section of the regulation, the CEQ provides definitions of "effects." Specifically, effects are defined as having two components: direct and indirect.

- *Direct effects* " . . . are caused by the action and occur at the same time and place."
- *Indirect effects* " . . . are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable" (40 CFR 1508.8). The CEQ regulation adds that indirect effects " . . . may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems."
- CEQ differentiates direct and indirect effects from the term "*cumulative impact,*" which " . . . is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. . . . "

The CEQ noted that the terminology of 40 CFR 1508.1 should be uniform throughout the federal government. Uniformity is reflected in the NEPA-implementing regulations of the various federal agencies, including those agencies of the U.S. DOT (i.e., U.S. Coast Guard [USCG], FAA, FHWA, FRA, FTA, St. Lawrence Seaway Development Corporation, and Maritime Administration). For example, the FHWA and the FTA reference the CEQ regulation for definitions in their NEPA-implementing regulation—23 CFR 771, Environmental Impact and Related Procedures.

CEQ regulations pertaining to the NEPA process can be found at 40 CFR 1500–1508. Cumulative effects are defined as discussed above, at 40 CFR 1508.7, and indirect effects are discussed at 40 CFR 1508.8. Other elements of the regulations relevant to indirect effects analysis include:

- *Integration of compliance procedures*—Integration is encouraged to reduced delay in project development and review. All permits, analyses, and procedures should be conducted concurrently rather than consecutively (40 CFR 1500.2). It is also stated that "environmental analyses and proposals of cooperating agencies" be used "to the maximum extent possible" while maintaining consistency with the lead agency responsibilities (40 CFR 1501.6). Funding for this work is expected to come first from the cooperating agencies, with secondary support from the lead agencies for "major activities and analyses" (40 CFR 1501.6).
- *Inclusion of interested parties*—"Federal, state, and local agencies," tribes, and "other interested persons" (40 CFR 1501.7). The regulations clarify that the likely "cooperating" agencies to be included are those with "jurisdiction by law or special expertise" (40 CFR 1501.6). In addition, the concept of inclusion is extended by the suggestion that this includes "those who might not be in accord with the action (project) on environmental grounds" (40 CFR 1501.7). Public involvement is to be "encourage(d) and facilitate(d)" (40 CFR 1500.2).
- *Time of compliance*—The time or place in the planning process at which integration should take place is stated as "the earliest possible time" (40 CFR 1501.2; 40 CFR 1201.3) or "the earliest time possible" (40 CFR 1501.6). Other statements, such as integrating NEPA into the "early planning process" (40 CFR 1500.5); preparing the environmental impact assessment "early" (40 CFR 1501.1); identifying issues at an "early stage" (40 CFR 1501.1); having an "early and open process for scoping"; and the possibility of holding an "early scoping meeting" (40 CFR 1501.7), reinforce the intent.
- *Interagency cooperation*—Cooperation among agencies in identifying impacts of concern before preparing the Environmental Impact Statement (EIS), during or even before formal scoping, is considered desirable. This was intended, in part, to avoid the "submission of adversary comments (by cooperating agencies and interested parties) to the completed (EIS) document" (40 CFR 1501.1).

- *Order of events*—The order of pertinent events identified in the CEQ regulation begins with pre-scoping, followed by a "Notice of Intent" to prepare an EIS published in the Federal Register. Lead agencies would then "request" (40 CFR 1501.5) cooperating agencies to participate in the planning process, or agencies could "request the lead agency to designate" (40 CFR 1501.6) it as a cooperating agency for involvement in scoping sessions.
- *Significance of impacts*—The CEQ regulation emphasizes a "systematic, interdisciplinary approach" (*3*, 40 CFR 1501.1) in identifying and analyzing impacts of proposed projects. The discussion suggests that with identification of environmental effects in the early stages of planning, "significant issues deserving study" can be differentiated from those that do not necessitate detailed analysis. This serves to "narrow the scope" (40 CFR 1501.1) of investigation, making the process more efficient and credible.
- *Integration of disciplines*—Cautionary passages alert lead agencies to "ensure the integrated use of natural and social sciences" as well as the "environmental design arts" in project planning and analysis (40 CFR 15072). It is stated that "the identification of environmental effects and values" should be analyzed "in adequate detail" and circulated at the same time as economic and technical analyses in order to give more balanced consideration of potential project effects.
- *Documentation of indirect effects*—Indirect effects are referred to specifically for inclusion in the "Environmental Consequences" section of the EIS documents (40 CFR 1502.6). Both short- and long-term environmental effects of land use, and a discussion of "means to mitigate" the negative effects, must be addressed.

ISTEA / TEA-21

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 was reauthorized and revised by Congress in 1998 as the Transportation Equity Act for the 21st Century (TEA-21; PL 105-178 as amended by PL 105-206). As with ISTEA, TEA-21 does not specifically refer to indirect effects analysis. Several provisions of TEA-21, discussed below, are important to note in a discussion of indirect effects, however.

- *End of the separate MIS requirement*—In a major departure from ISTEA, TEA-21 eliminates the requirement for a separate Major Investment Study (MIS) prior to consideration of any substantial transportation project. The statute (§ 1308) calls for the integration of the MIS into the general transportation planning process required of state agencies and Metropolitan Planning Organizations (MPOs). The MIS incorporates a wide range of considerations including indirect effects. The ultimate purpose of an MIS is to evaluate the cost-effectiveness and overall effectiveness of alternative investment strategies by examining the direct and indirect costs of alternatives as well as improvements to mobility and accessibility. The MIS explores the full range of impacts on the natural, social, and economic environments, in addition to showing impacts on safety, operating efficiency, economic development, land use, and energy consumption.

FHWA and FTA have proposed revisions to regulations (65 FR 33928) on statewide and metropolitan transportation planning to account for the TEA-21 mandate to integrate the goals of the MIS into the planning process. The revisions give agencies the option to conduct environmental analyses, including analysis of indirect and cumulative effects, during the statewide or metropolitan planning process. Several aspects of the proposed regulations are important to note.

– The participation of federal agencies in analyses at this stage would be encouraged, and the product of analyses conducted at this level could be used for subsequent project review under NEPA.
– Agencies would be encouraged to conduct planning- and systems-level reviews to a standard that would meet data and analytical expectations for subsequent NEPA review. Any level of analysis, however, will be reviewed by participating agencies at the NEPA stage. To the extent to which planning analyses meet NEPA requirements in the evaluation of alternatives, they will allow for a streamlined process with the focus on project level design considerations.
– Robust documentation of planning activities and environmental analyses would not be required but would facilitate the linkage between systems planning and project review, streamlining the process.

The revisions were drafted after an extensive period of comment and review on potential options. More stringent requirements promoting NEPA compliance at the planning stage were rejected by most stakeholders. Similarly, options requiring regional or sub-regional analysis of indirect and cumulative effects, or a mandate for evaluation of those effects at the systems planning stage, were also criticized by stakeholders as too onerous. Several stakeholders also commented that the state of the practice in data gathering and methods was not sufficient to the task of universal evaluation of secondary and cumulative effects early in the process. These comments shaped the ultimate form of the proposed regulations which merely encourage, but do not mandate extensive analysis early in the transportation development process. However, it should be noted that to be eligible for FTA capital investment grants and loans, new fixed guideway systems or extensions ("new starts") must be evaluated pursuant to the criteria of 49 CFR 611. TEA-21 added several relevant considerations to the project evaluation process, including the cost of sprawl and infrastructure cost savings due to compact land use.

- *NEPA streamlining*—Another important element of TEA-21 relating to environmental impacts is the streamlining of environmental review (§ 1309). Streamlining means that the U.S. DOT will encourage cooperatively developed time frames so that all relevant agencies are working efficiently. It also allows for concurrent rather than sequential review of documents and the opportunity for states to be included in this expedited process. Streamlining is meant to encourage the early analysis of project effects.
- *Planning considerations*—The separate planning factors that were to be considered by state agencies and MPOs under ISTEA were a consolidated under TEA-21 into seven broad areas of consideration (§ 1203, § 1204). These considerations include the following:
  – Support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity, and efficiency;
  – Increase the safety and security of the transportation system for motorized and nonmotorized users;
  – Increase the accessibility and mobility options available to people and for freight;
  – Protect and enhance the environment, promote energy conservation, and improve quality of life;
  – Enhance the integration and connectivity of the transportation system, across and between modes, for people and freight;
  – Promote efficient system management and operation; and
  – Emphasize the preservation of the existing transportation system (§ 1203, § 1204).

Several of these factors can be achieved through the consideration of the indirect costs and benefits of projects. These include, economic vitality, accessibility and mobility, and environmental, energy conservation and quality-of-life improvements.

Although implementation of TEA-21 is still being formalized, it is clear that consideration of indirect effects on a regional level, at the planning stages, or early in the project process is an important step toward meeting the goals of TEA-21.

Environmental Justice

Executive Order 12898 issued by the President in 1994 calls for an evaluation of the impacts of any federal investment on minority and low-income groups. Indirect effects, then, must now be evaluated for their significance in the environment as a whole, and among certain disadvantaged classes.

Environmental justice requires the identification and mitigation of disproportionately high adverse effects. Adverse effects in this context are defined as "the totality of significant individual or cumulative, human health, or environmental effects, including interrelated social and economic effects" (section 2f). Disproportionate effects are those borne predominately by minorities and low- income groups or suffered by those groups appreciably more than other groups.

An example of indirect effects in the context of environmental justice is given by the EPA in its 1998 guidance on environmental justice:

> Increased urbanization may occur around a new facility due to increased employment or due to transportation system upgrades. This may result in disproportionately high and adverse effects to low-income communities due to increased air pollution, lower housing values, and reduced access to fishing/farming locations.
> (section 2.2.2)

The FHWA in its guidance on the subject notes that in addition to the direct and indirect effects of a project on low-income or minority populations, an agency must also consider multiple exposures and cumulative effects. Effects of previous actions may be unrelated to the project under consideration but could be significant and disproportionate in interaction with or combination with direct or indirect project effects. To properly evaluate these effects, a broad look at the state of the current environment and its future state under a baseline "no-action" alternative must be considered. The totality of indirect effects, project and non-project related must be considered.

In addition to cumulative effects, the FHWA notes that offsetting benefits of a direct or indirect nature must be considered when evaluating projects. Benefits overall to an affected population may outweigh disproportionate adverse impacts. Impacts should also be evaluated comparatively—if the same system elements or impacts are present in non-minority or higher-income neighborhoods, the impact may not be considered disproportionate.

Even if disproportionate effects are identified, a project may still be allowed to go forward if mitigating measures are not practicable or if other alternatives have a greater adverse impact on the affected population or overall. The social, economic, and environmental effects of mitigation and alternative projects must be considered here as well has the harm to the public good if a project is not pursued.

In sum, in recent years the importance of avoiding impacts that disproportionately affect minority or low-income populations, even if those impacts could be considered insignificant overall, has been recognized. Indirect effects are important here because they are just as likely to be disproportionate in nature. Project- and non-project-related indirect effects can also factor into the cumulative impacts on a population. Indirect benefits and costs may also help determine whether offsetting positive impacts are present or whether mitigation or the no-build option are impracticable.

Environmental Justice Evaluation Approach

A framework for assessing the benefits/burdens of indirect effects on different socioeconomic groups should be similar to the framework used for other types of indirect effects. First, assess the no-build scenario, that is identify the benefits/burdens of the existing transportation system on low-income or minority populations. Some questions to consider include: Does the existing transportation system adequately serve the needs of these groups in terms of access to jobs, services, and community facilities? Are there development/redevelopment plans in place that target these groups and communities?

Once the no-build situation is established, then a build analysis can be performed within the overall indirect effects estimation framework. Using the indirect effects typology (see Course Module 1, Figure 1-3), identify whether the transportation systems can have encroachment alteration effects that burden low-income and minority groups; for example, a linear transportation facility can isolate communities, or portions thereof, from employment opportunities, services, or community facilities (schools, parks, community centers, libraries, etc.). These type of effects can be estimated by an inventory and mapping (see Course Module 5) of the locations of these user destinations, combined with a user survey of activity patterns, modes, routes of access, and so on. In other cases, provision of a transportation service can improve such access in measurable ways.

The second type of indirect effect, development influencing effect of transportation systems, can also support a benefits/burdens indirect effects analysis. For example, where a transportation improvement complements a plan to target development or redevelopment to a low-income or minority community, there can be a benefit. In other cases, the transportation improvement can disproportionately burden an area by drawing away development that might otherwise have occurred in a low-income or minority community, to a location with other socioeconomic attributes (i.e., the intra-metropolitan shift, from a rural or inner-city location, to a suburban location). A complex number of factors come into play; however, the questions of disproportionate development shifts need to be asked, preferably at the regional level.

The third type of indirect effect, effects related to development influencing effects, can also support a benefits/burdens indirect effects analysis. For example, if a transportation improvement, such as a highway access to a port intermodal facility, is planned, and the highway passes through a low-income or minority community, then questions should be asked about whether the burdens (e.g., noise and air pollution from trucks using the highway) are balanced with the benefits (e.g., employment opportunities).

With any of these types of indirect effects, if the burdens outweigh the benefits, then mitigation should be targeted toward enhancing the benefits, avoiding or minimizing the burdens, and/or compensating for the burdens.

EXAMPLES OF INDIRECT EFFECTS GUIDANCE DEVELOPED AT THE STATE LEVEL

Several states have developed or are in the process of developing guidelines on the analysis of indirect effects for state agencies with responsibility for transportation development and environmental review. The guidance documents of three states, Wisconsin, Maryland, and Florida, are summarized below in outline form.

Wisconsin

In 1996, the Wisconsin DOT produced *Technical Reference Guidance Document on Indirect and Cumulative Effects Analysis for Project-Induced Land Development.* This document outlined several steps in the identification and analysis of indirect effects.

1. Define the Project Study Area:
   a. Trafficshed
   b. Commutershed
   c. Growth Boundary
   d. Interview
2. Analyze Existing Patterns and Trends for Land Use and Development:
   a. Distinguish between developed areas and rural areas, noting land use types
   b. Identify areas of natural resource interest
   c. Describe past and projected future population for jurisdictions in the study area
   d. Develop no-build, probable future development scenario
3. Analyze the Extent of Land Use Planning and Regulation:
   a. Inventory relevant land use plans
   b. Note any statements about the proposed project and/or future land development
   c. Develop probable future development scenario based on plan
4. Understand the Type of Project, consider design characteristics and impacts:
   a. Location
   b. Access management
   c. Capacity
   d. Travel patterns
   e. Traffic control
5. Assess the Potential for Project-Induced Land Development:
   a. Draw from existing Transportation Improvement Program (TIP), MIS, or other regional transportation plan
   b. Identify any existing development proposals that are dependent upon a project alternative
   c. Design an analysis approach that involves expert involvement and public expertise
   d. Describe effect and magnitude of potential impacts
   e. Indicate whether impacts are incompatible with adopted land use plans
6. Assess the Potential Consequences to the Human Environment:

a. Where development plans are known, describe impacts
b. Where location and extent of development are not known with certainty, provide general descriptions of the types of impacts associated with anticipated patterns of development

7. Identify Tools and Key Actors in Management of Land Development:
   a. Facility design and access management
   b. Planning
   c. Regulation
   d. Education

Maryland

In the late 1990s, Maryland DOT produced guidance materials to assist in Secondary and Cumulative Effects Analysis (SCEA) for DOT projects. The guidance outlines basic procedures for scoping, analysis, and mitigation.

1. Scoping involves identification of the following:
   a. Area resources
   b. Existing, readily available data sources
   c. Preliminary SCEA study area based on project, resource, census, political, and infrastructure boundaries
   d. Time frames, relevant past, present, and reasonably foreseeable future periods for analysis
2. Analysis involves quantitative and qualitative techniques using existing data sources:
   a. Refining the study area boundary (should be periodically reexamined as analysis progresses)
   b. Data collection and mapping of past and present land uses
   c. Forecast of future land use patterns
      i. local planning agency projections, master plans, zoning build-out
      ii. land use assumptions from travel forecast effort
      iii. expert panel
      iv. interviews with officials, developers to determine development that *may occur* and development that can not occur *but for* the proposed project.
      v. access controls are a key factor, uncontrolled access more likely to produce secondary impacts-controlled access leads to interchange impacts.
   d. Determination of secondary impacts for each alternative
   e. Evaluation of cumulative impacts by adding direct and secondary effects to likely impacts of other actions
   f. SCEA summary for each alternative describing methodology, assumptions, and findings. Limits of SCEA due to lack of readily available data should be fully documented.
3. Methods for SCEA:
   a. Trend analysis—projecting historical trends to future periods
   b. Map overlays—overlaying present and future land use maps on resources mapping to visualize impacts
   c. Matrices—tables comparing impacts with resources over time
   d. Interviews—experts answer questions regarding potential effects
4. Mitigation and Monitoring:
   a. Possible mitigation strategies to be undertaken by local land use authorities should be suggested in cases where significant secondary effects are identified
   b. State highway administration may work with local jurisdictions to develop access controls or develop resource preservation plans.

Florida

In a report for the Florida DOT (*Secondary and Cumulative Environmental Impacts of Transportation Projects,* 1998), the Florida Atlantic University/Florida International University Joint Center for Environmental and Urban Problems describes a six-step process for indirect and cumulative effects analysis:

1. Determine Study Area, options include:
   a. Trafficshed
   b. Commutershed
   c. Growth boundaries
2. Estimate Available Land/Develop Growth Scenarios, options include:
   a. Low-growth scenario—development on unconstrained available land
   b. Moderate-growth scenario—development on unconstrained land plus one-half partially-constrained area (flood-fringe, agricultural area, conservation areas)
   c. High-growth scenario—development on unconstrained land plus partially-constrained land
3. Choose Likely Growth Scenario, considerations include:
   a. Rate of growth in area—low growth area unlikely to yield impacts
   b. Findings in comparative cases
   c. Proximity to growth centers (use gravity model measure attractiveness due to improved accessibility)
   d. Expert interviews/panel
4. Assess Likely Induced Growth Impacts, considerations include:
   a. Access controls
   b. Growth management/land use controls
   c. Infrastructure availability
   d. Historical trends
5. Evaluate Secondary (induced-growth related) Environmental Impacts:

   a. General qualitative review of potential impacts
   b. Resource map overlays
6. Describe Tools Available:
   a. Detail mitigation effort to be carried out by DOT
   b. Identify stakeholders outside DOT with authority over land use and environmental matters
   c. Develop conceptual plans for efforts that can be taken outside of DOT

RESOURCES AND SUPPLEMENTARY READINGS

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COURSE MODULE **2**

REVIEW OF CASE LAW ON INDIRECT EFFECTS EVALUATION

OVERVIEW

The environmental impact assessment process has been shaped by a framework of laws and regulations at the federal and state levels. These standards have, in turn, been modified and clarified by the courts through major decisions of the United States Supreme Court, Federal Appeals Courts, Federal District Courts, and various levels of the state court systems. The evaluation of indirect effects in the NEPA process has been the subject of a growing number of cases in the courts and knowledge of this body of case law is invaluable in guiding the approach that should be taken by practitioners. Ultimately, agencies involved in the analysis of the indirect effects of transportation project must tailor their evaluations to comply with applicable laws and regulations as interpreted by the courts. Review of current case law standards will help ensure that practitioners construct an approach to indirect effects evaluation that will produce better transportation projects, result in wise use of taxpayers' money, and withstand court scrutiny.

This module will cover several key topics and developments in recent case law. Questions related to the evaluation of indirect effects that will be addressed in this module include:

- What is the legal basis for analysis of environmental impacts?
- What are the general standards for legal review of environmental impacts?
- When is an action considered a "major federal action" requiring NEPA evaluation?
- What are the general requirements for the preparation of an EIS?
- When should potential impacts be considered *significant?*
- When are significant impacts *reasonably foreseeable?*
- What are the standards for a Finding of No Significant Impact (FONSI), or a decision not to supplement an EIS?
- What are the standards used by federal courts to review the content of an EIS?
- What constitutes an adequate evaluation of indirect effects in an EIS?
- What is the effect of land use and zoning controls on indirect impact analysis?
- Where do the courts stand on the issue of environmental justice?

Throughout this module, court decisions supporting or related to answers to the above questions will be referenced by a boldface number in parentheses. Cases referenced are listed at the end of this module.

What Is the Legal Basis for Analysis of Environmental Impacts?

NEPA requires preparation of an EIS for all major federal actions (see Questions 2 and 3 below) that significantly affect the quality of the human environment. The requirement for an EIS is the primary mechanism that enables NEPA's key aims to be met. These aims are as follows:

- To ensure that all federal agencies' decisions on major actions or proposals will be informed by detailed analysis of the significant environmental impacts of a proposal.
- To guarantee that this information will be available to the public, whose concerns and insight may then be incorporated into the decision through the comment process (**1**).

An EIS must consider all reasonably foreseeable, significant direct, indirect, and cumulative impacts. It should be noted however, that

- Although NEPA requires that agencies take a "hard look" at all significant environmental impacts, the statute's twin aims mandate a procedural process, not a substantive result (**2**).
- If "the adverse environmental effects of the project are adequately identified and evaluated, the agency is not constrained by NEPA from deciding that other values outweigh the environmental costs" (**2**).

In large measure, then, NEPA "guards the environment through discussion and disclosure" (**3**).

What Are the General Legal Standards for Legal Review of Environmental Impacts?

The primary standards on which legal review of environmental impacts is based are the CEQ regulations. These regulations implement NEPA and control the EIS process through guidance of scoping, alternatives analysis, and impact identification and evaluation. They are binding for all federal agencies. The CEQ regulations include some important definitions cited often by the courts (definitions are discussed in greater detail in Module 1):

- *Direct impacts*—caused by the action, occur at the same time and place.
- *Cumulative impacts*—those actions, which when viewed with other proposed actions, including past, present, and reasonably foreseeable future actions, have cumulatively significant impacts and therefore should be discussed in the same impact statement (**4**).
- *Indirect impacts*—linked to action/project, reasonably foreseeable, can include project-influenced changes, and effects from such growth (e.g., changes in the pattern of land use) and related effects on natural systems. Indirect effects, secondary impacts, and growth-inducing effects are one and the same in federal case law.
- *Major and federal actions*—NEPA requires preparation of an EIS for all major federal actions significantly affecting the quality of the human environment. Major federal actions are those that are subject to federal control and responsibility, including "projects and programs entirely or partly financed, assisted, conducted, regulated or approved by Federal agencies." This applies to most transportation projects (see also Question 3 below).
- *Statute of limitations*—Private actions involving NEPA claims are subject to the 6-year statute of limitations under the Administrative Procedure Act (APA). Issuance of the record of decision (ROD) approving the FEIS, constitutes the final agency action at which time the statute of limitations commences (**5**).

When Is an Action Considered a "Major Federal Action" Requiring NEPA Evaluation?

To determine whether a project constitutes a "major federal action," courts use one of two approaches:

1. The "dual approach" analyzes both the scope of the federal involvement in the project; and the significance of the project's environmental effects. Under this dual approach, the federal involvement has to be major in order for an EIS to be required for the project (**6**). This approach can however mean that a project that is regarded as a "minor federal action" but which may have "major" environmental impacts, can circumvent the EIS process, which defeats one of the key purposes of NEPA.
2. The "unitary approach" has been used by some circuits and has been expressly adopted by the CEQ regulations. This approach allows any federal project that will have a significant effect on the environment to be considered as though it were a major federal action (**7, 8**).

When a proposed private and/or state action with significant environmental impacts involves minimal or marginal federal agency action, the question arises whether the federal agency must prepare a comprehensive EIS that evaluates the environmental impacts of the *entire* project, not just the smaller piece or pieces involving the federal agency. This dilemma is commonly referred to as the "small handles" problem. The unitary approach partially resolves the small handles problem. However the question still remains as to whether federal involvement in a project is sufficient to "federalize" the whole project, thus requiring a full EIS for the entire project.

Courts have determined that a project should be considered federal in nature when the federal involvement is significant enough to the project in its entirety—including the non-federal aspects of the project—so as to "federalize" the entire project (**9, 10, 11**). A project is regarded as "federalized" when the non-federal portions of the project require federal action before legally going forward. However a project may also be regarded as federalized without such legal authorization, if a court decides that the federal and non-federal components of a project are interdependent. Conflicting opinion exists as to whether a project should be regarded as federalized in situations where federal action is not a legal requirement for a project but a federal agency has control over the progress of the project as a consequence of the need for its approval. Courts have generally been reluctant to require NEPA compliance for portions of projects that include neither federal funding nor substantive federal involvement in decisionmaking.

When determining whether federal involvement is sufficient to federalize a project, courts examine the connection between the federal and non-federal components of the project. In general, analysis considers whether the federal and non-federal components are interdependent or merely complementary. Courts have found in some cases that private and federal agency actions were interdependent and entire projects should therefore be federalized, requiring a comprehensive EIS for all aspects of the project. In other cases, courts have found that separate sections of the same project serve complementary but distinct functions and should therefore be treated separately. Courts have been careful to distinguish, however, cases where certain segments of projects were deliberately designated as "state" and others as "federal" projects in an effort to avoid the requirements of NEPA.

Most transportation actions involving indirect effects are clearly "major federal actions" subject to federal control and responsibility by nature of being "entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies" 40 C.F.R. § 1508.18(a). In those situations where significant indirect effects stem from non-federal portions of a larger project, courts analyze the nexus between the federal and non-federal components to determine if they are interdependent, thus federalizing the entire project, or merely complementary, in which case the non-federal aspects need not be evaluated in an EIS.

What Are the General Requirements for the Preparation of an EIS?

Timing: EIS Need Only Be Prepared for Actual Agency Proposals

In *Kleppe v. Sierra Club* (**27**), the Supreme Court limited the need to prepare an EIS only to those contemplated agency actions which are definitive or concrete proposals, evidenced by a formal report (as opposed to conceptual or exploratory plans or ideas). However, subsequent cases have demonstrated that it is not always clear when a definitive proposal exists.

- The current CEQ regulations, which largely codify standards developed in previous federal case law, attempt to define and clarify this standard. "A 'proposal' exists at that stage in the development of an action when an agency . . . has a goal and is actively preparing to make a decision on one or more alternative means of accomplishing that goal and the effects can be meaningfully evaluated . . . A proposal may exist in fact irrespective of whether there is an agency declaration that one exists." Courts have used these regulations to prevent agencies from circumventing NEPA through vague or limited definition of their proposals.
- The *Kleppe* case illustrates the significance of case law. The results of the case "ended one way that NEPA could be used . . . Had *Kleppe* gone the other way, NEPA might have compelled more agencies to think, and plan ahead, and thus understand the long term consequences of their actions. Agencies can avoid NEPA's requirement to act with foresight by defining their plans in a limited way" (Thatcher, 1990).
- The *Kleppe* case is also significant in relation to challenges to an EIS, because it raises the issue of when during an EIS it is advisable to sue an agency. If a suit is brought too early it may fail because the agency is judged not to have reached the "proposal stage" with its plans. If plaintiffs act too late then the "proposal" may have progressed to the point where its outcome has become inevitable.

Scope of an EIS

One of the key threshold decisions for transportation projects is the determination of an EIS's scope. "Although agencies are given 'considerable discretion' in defining the scope of an EIS, connected actions must be considered together" (**1**).

Under the CEQ regulations, connected actions include those which:

- Automatically trigger other actions for which an EIS may be required;
- Can not or will not proceed unless other actions are taken previously or simultaneously;
- Are interdependent parts of a larger action and depend upon that larger action for their justification (**28**).

Agencies may not attempt to avoid NEPA's requirements by dividing transportation projects into several smaller actions or component parts, each of which, considered separately, may not have significant environmental impacts, but if evaluated together, have substantial impacts (**30**). Cumulative actions must be considered in determining the scope of an EIS. Cumulative impacts of distinct, independent projects, must be included in the scope of an EIS when the actions considered together with the proposed transportation project would have significant environmental impacts (**4**).

In *Thomas v. Peterson* (**35**), the U.S. Forest Service concluded that construction of a 25-mi timber road would have no significant environmental impact. The Forest Service did not, however, consider the separate environmental impacts of harvesting and subsequent transport of timber, which was the reason the road itself had been proposed. The court held that the environmental impacts of the road's construction and the cutting and transporting of timber were connected actions that must be considered together in an EIS. Because the sale of timber could not proceed without the road and the road had no other justification except to provide access to the timber, the two actions were "inextricably intertwined."

When Should Potential Impacts Be Considered *Significant?*

Determination of when an environmental impact should be considered significant is guided by CEQ regulations. Significance within NEPA includes both context and intensity:

- *Context*—the significance of an action must be broadly analyzed in the context of its impacts (i.e., within society, site specific, locally, or regionally etc.), as significance varies with setting.
- *Intensity*—the severity of the impact. Decisions on severity may vary among agencies. CEQ regulations list 10 factors used to evaluate intensity (see discussion in Module 7).

The focus of any EIS should be on the significance of any impacts, irrespective of whether such impacts can be considered direct, indirect, or cumulative (**8**).

When Are Significant Impacts *Reasonably Foreseeable?*

Under NEPA, an EIS should include all reasonably foreseeable impacts, not all conceivable impacts (**11**). This means that all potentially significant future impacts must be evaluated, but may be ignored if the impact is improbable although possible, or if the impact is too uncertain to make reasonable evaluation of it possible. CEQ guidance emphasizes the use of informed judgement when evaluating uncertain but probable effects and those that are too speculative and improbable.

- Reasonable forecasting and speculation is implicit in NEPA (**12**). CEQ guidelines state that an agency can not ignore uncertain, but probable, effects of its decisions.
- Recent cases reserve use of the term "speculation" to distinguish between required "reasonable forecasting," and what is probable, and unreasonable contemplation of "highly speculative" future impacts (**11, 12, 13**). The First Circuit has noted that an environmental impact would be "too speculative" for inclusion in an EIS if it can not be described at the time the EIS is drafted with sufficient specificity to make its consideration useful to a reasonable decision. As a general rule, significant impacts are reasonably foreseeable if they are not too speculative or improbable.

What Legal Standards Are Used to Review a FONSI or a Decision Not to Supplement an EIS?

NEPA and the CEQ regulations allow a lead agency to decide that a project or proposed action does not require an EIS because it will not have a significant effect on the quality of the human environment. This is a Finding of No Significant Impact (FONSI).

Before it can reach a FONSI decision, an agency must take a hard look at all potentially significant environmental consequences of the proposed actions. There have been a number of cases where a challenge to a FONSI decision has resulted in a federal or district court judgement. It should be noted that a reviewing court may overturn an agency's FONSI and decision not to prepare an EIS. In case law, the decision whether or not to supplement an EIS is judged in the same way as the decision whether or not an EIS is required at all.

Prior to 1989, there was a division between federal circuits as to which standards should be used to review agency FONSI, EIS preparation, and supplementation decisions. A small number of courts used the "arbitrary and capricious" standard, while the majority used the "reasonableness" standard.

- The ***arbitrary and capricious*** standard of review has been used by all courts since 1989, when a Supreme Court decision finally resolved the previous division of opinion (**14**). This standard now applies to all review of an environmental assessment, FONSI (**15**) and decision not to prepare or supplement an EIS (**16, 17, 18**). This is the standard of review most deferential to an agency's expertise in technical matters. Under this standard, a reviewing court must defer to an agency's choice of evidence, methodology, and expert opinion in support of a decision (**19**) unless it is determined that the agency made a decision not supported by the evidence before it, that it is implausible that the discrepancy between evidence and decision be attributed to a difference in viewpoint or agency expertise, that the agency based its decision on factors not intended under NEPA, or that the agency failed to consider a critical issue or type of significant impact (**15, 20**). This standard does not, however, apply when a court is considering the content of an EIS. In such cases, the *reasonableness* standard is used (**3**).
  - The party challenging an agency's FONSI bears the burden of establishing that the agency's decision was arbitrary and capricious (**17**).
  - Although it has been suggested that a court reviewing an environmental assessment and FONSI need only consider challenges to evidence, methodology, or expert opinion if they were raised during the environmental assessment comment period (**16**), courts still have discretion to consider evidence or opinions not officially part of the environmental assessment administrative record when reviewing an agency's FONSI (**15**).
- Until 1989, the majority of courts applied the more stringent *reasonableness* standard of review to environmental assessments, FONSIs, and decisions not to supplement an EIS. The court analyzes the statement's evaluation of significant environmental impacts, while reviewing the administrative record upon which it was based, in order to determine the "reasonableness" of the agency's decision (**3, 11**). This standard provides more opportunity for a reviewing court to overturn court decisions. After 1989, this standard was replaced in these areas by the *arbitrary and capricious* standard, although it continues to apply to review of the adequacy of the content of an EIS (**21**).

What Are the Standards Used by Federal Courts to Review the Content of an EIS?

The adequacy of the content of an EIS is always reviewed using the *reasonableness* standard. Courts use this standard to analyze an EIS to determine whether it contains a "reasonably" thorough discussion of significant aspects of probable environmental consequences (**3**). Their analysis is based on the following factors:

- The form, content, and preparation of an EIS must foster both informed decisionmaking and informed public participation.
- The EIS must contain a full discussion of all agency inquiries, analysis and reasoning (**11**). Listing or cataloging of possible impacts is not acceptable (**19**); neither are general statements about "possible" effects and "some risk" (**29**). All evidence that an agency wishes to be considered by the court must be contained within the EIS itself.
- As is the case with the *arbitrary and capricious* standard, courts evaluating the adequacy of an EIS using the *reasonableness* standard must defer to the agency's

informed choice of experts, evidence, and methodology unless there are errors or omissions, which, if resolved, would have led to a different EIS decision (**11, 19**). NEPA does not require that courts decide whether an EIS is based on the best scientific methodology available.

- Information that is relevant or necessary to make an informed decision concerning significant environmental impacts may in some instances be infeasible to collect or analyze. Early CEQ regulations required preparation of a "worst-case analysis" in an EIS to account for the lack of information. This was amended in 1986 because it required excessive agency resources for technical studies to satisfy the worst-case requirement (Findley & Faber 1996).
- Under the 1986 CEQ regulations, agencies are required to obtain unavailable or incomplete information if technically and economically feasible. Agencies faced with incomplete or unavailable information concerning a reasonably foreseeable significant environmental consequence must prepare a summary of existing credible scientific evidence and evaluation impacts based on theoretical approaches or research methods generally accepted in the scientific community (**1**).
- Once a court is satisfied that an agency has taken a "hard look" at the environmental consequences of a decision, the role of the court is complete. A court can not substitute its own judgement for that of the agency in considering the prudence or appropriateness of a proposed action (**30**).

What Constitutes an Adequate Evaluation of Indirect Effects in an EIS?

Although there is a considerable quantity of federal case law focusing on cumulative effects analysis in an EIS, the number of reported cases dealing with indirect effects of proposed transportation projects is limited. This section includes cases which provide general legal guidance for determining when indirect project effects (such as induced residential or commercial growth) and associated adverse environmental impacts, are significant and sufficiently probable so that they must be analyzed in an EIS (**21**).

- *Level of detail*—Recent indirect effect cases provide little guidance as to the level of detail with which secondary impacts must be analyzed in an EIS to satisfy NEPA, or how local or regional planning documents and studies may be used to support or refute arguments that growth-induced development was already planned, inevitable, or preventable under existing zoning and other local land use controls. Although a listing or cataloging of potential impacts in an EIS is not acceptable (**19**), the few cases on record to date have not required more than a more descriptive listing of possible impacts (**22, 23**). Although in some cases courts have reviewed the types of indirect effects that must be considered under NEPA and CEQ regulations, most cases where the court has held in favor of the agency's EIS do not involve the discussion of specific secondary impacts discussed in the EIS, or describe why the analysis of these impacts was adequate under NEPA.
- *Induced growth as a selling point*—The economic benefits of project-induced residential or commercial growth have been promoted as "selling points" for proposed transportation projects (**24**). Reliance on these benefits confirms such indirect effects as probable, reasonably foreseeable, and potentially significant. Courts have ruled against agencies who have used future project economic benefits to promote a development but have not prepared an EIS to assess the indirect impacts of these benefits (**25**).
- *Adequacy of assessment*—There have been several cases where an agency environmental assessment or EIS for a transportation project has been challenged on the grounds that secondary impacts, including induced growth and development, have not been adequately assessed. These cases are more useful in providing guidance on the expectations of the courts. Such cases emphasize that an EIS must identify and analyze the growth-inducing effects of transportation projects that are significant, reasonably foreseeable, and probable. Some of the more instructive cases are summarized below.

Gloucester County Concerned Citizens v. Goldschmidt (**21**)**—**Plaintiffs challenged an FEIS for a proposed highway on the grounds that it did not adequately consider secondary impacts, which they considered would be significant. The court found against the plaintiffs, stating that they had not demonstrated that secondary impacts were significant and that the failure of the FEIS to speculate on future and improbable events did not constitute a serious deficiency in the FEIS. The court found that the FEIS had adequately evaluated the project in its existing context, and that growth in the project area was likely irrespective of the proposals.

City of Davis v. Coleman (**8**)**—**This case involved a proposal to build an interstate highway interchange to stimulate and service future development in a rural area. Neither an environmental assessment nor an EIS was prepared. Instead, a three-page "Negative Declaration of Environmental Impact" was issued. This declaration neither identified nor discussed the commercial and industrial development that would likely spring up around the interchange, located in a "sparsely populated agricultural area," instead assessing only the direct impacts related to the construction of the interchange. The court held that the failure to identify and analyze the project's indirect effects violated NEPA, and noted the significance of the growth-inducing effects of the proposed development, which were essential to the project objectives. Although uncertain, these effects were reasonably foreseeable, and indeed probable. Not being able to predict the exact type of development that would occur could not be used as an excuse for failing to prepare an EIS evaluating the indirect effects of the project. Reasonable forecasting of project-induced development must be conducted in an EIS.

Coalition for Canyon Preservation v. Bowers (**34**)**—**This case involved a proposal to widen a 10.8-mi section of a narrow, two-lane federal highway that connected four small, rural towns in northern Montana and served as the primary access road into Glacier National Park. The widening would create an 88-ft-wide, four-lane highway, including 10-ft parking lanes with new curbing and other improvements in the sections passing through the towns, resulting in the relocation of several business. The EIS admitted that the wider four-lane highway could result in project-induced development, but did not assess the indirect impacts of such growth. The court held that the EIS's failure to assess this foreseeable development violated NEPA, as it did not analyze secondary effects.

Sierra Club v. Marsh (**26**)**—**A court used a three-part test to determine whether a particular set of indirect impacts were definite enough to be evaluated or too speculative to warrant consideration:

- Can one be confident that the impacts are likely to occur?
- Can the impacts be sufficiently described and specified *now* to allow for useful evaluation?
- If impacts are not evaluated now, will future evaluation of impacts be irrelevant because an agency will be irreversibly committed to a project or because the progress of future events is inevitable?

If answers to all three tests are positive, then indirect impacts are definite enough to be evaluated within an EIS.

In this case, the First Circuit reviewed a NEPA challenge to a proposed port and causeway on a rural island in Maine. The agency's environmental assessment had resulted in a FONSI and decision not to prepare an EIS for the project. The court evaluated the adequacy of the environmental assessment under the *reasonableness* standard applied before 1989. Using the three-part test, the court reviewed the administrative record of the project. Development of an industrial park would follow construction of the port, a "two-part development package." The record also included an environmental assessment prepared by the Maine DOT, which projected further industrial development after construction of the cargo port. This clearly satisfied the first test; there was ample "confidence" that indirect impacts were likely to occur.

Other documents reviewed by the court provided detailed descriptions of likely further development, analysis of the physical characteristics of the island, discussion of the feasibility of construction, analysis of development options, and evaluations of likely impacts on employment and housing conditions and municipal services. The court noted that the CEQ regulations do not require that the agency engage in speculation, but direct the agency to consider "likely purchasers [of land] and the development trends in the area . . . in recent years." The court then noted that the "land use" and "response" plans were detailed enough for evaluation to satisfy the second test, the impacts could be described and specified now to allow for useful evaluation in an EIS.

The case also met the third test, in that the court held that once the causeway and port were built, the pressure to develop the rest of the island could prove irresistible and unstoppable. Accordingly, putting off their evaluation in an EIS for some later time would result in environmental knowledge that would not offer the decisionmaker a meaningful choice whether to proceed.

Because the indirect effects of industrial development expected to result from construction of the port and causeway had been identified and specifically described in the planning documents, which projected with considerable confidence that such development would occur, the *Sierra Club III* court held that the failure to prepare an EIS evaluating these impacts violated NEPA. Analysis of these effects could not be conducted at a later date because once construction of the port and causeway neared completion, it would be too late to account for the indirect development, which would be a foregone conclusion.

What Is the Effect of Land Use and Zoning Controls on Indirect Impact Analysis?

In evaluating indirect effects as part of an EIS, agencies may rely on local or regional plans or planning documents, economic development studies, or zoning and other land use controls. In recent cases, EISs have been challenged on the grounds that agency evaluations of indirect impacts relied improperly or unreasonably on planning studies and documents (**3, 30**). The challenges in these cases related to the adequacy of the EIS's evaluations of project-influenced effects.

Agencies have concluded that project-influenced effects were already planned and accounted for within existing and accepted planning and development control, which assumed construction of the proposed project. Plaintiffs have argued that planning documents relied upon in EISs authorize development but do not require or guarantee it. Courts have ruled against these claims, finding that the EISs have adequately identified and evaluated the potential for project-influenced changes. These findings were based on the fact that the courts accepted that the EISs had acknowledged that the projects did have the potential to facilitate the rate but not the amount and pattern of project-influenced effects, both of which were considered inevitable.

Agencies have also claimed evaluation of transportation project-influenced effects is not necessary because the existence of land use and zoning controls, prohibits, and protects against such influenced development. In a number of cases (**26, 31**), agencies have suggested that indirect effects such as project-influenced effects need not be evaluated in an EIS because development growth could not occur without changes in local land use and zoning controls, and therefore would not occur on its own as an indirect impact of the proposed project.

In responding to challenges, courts have accepted the agency position that significant changes in development patterns can only be caused by zoning changes and not by specific projects. The following case illustrates this point:

- *Florida Wildlife Federation v. Goldschmidt* (**33**). This case involved expert testimony claiming that the political vulnerability of existing land use planning controls made them ineffective in limiting development. The case centered on the proposed extension of Interstate 75, which the plaintiffs claimed would induce massive residential, commercial, and industrial development. The defendant's arguments centered on the existing Land Use Plan for Broward County, which had been developed over a 3-year period, following numerous studies and hearings. The plan had the full force and effect of law throughout the county, with a stringent and lengthy procedure for adoption of amendments. The court held that the evidence pointed strongly against induced development:

> In short, plaintiffs' fears that I-75 will induce massive, total development of the study area have little evidentiary support. Though it may be true as a general rule that access to transportation causes development, the history of and projected increases in population growth for south Florida demonstrate that growth will occur because of market demands even when transportation is lacking. There is already some development in the study area, and development will continue there as planned and allowed under Broward County's Land Use Plan, whether or not I-75 is constructed, because it is the next logical area for development. All the evidence indicates that the Land Use Plan is, and will continue to be, enforced.

Although no clear standards have emerged regarding the use of local or regional planning documents and studies in growth-induced development cases, it is evident that courts will consider the role of planning and land use controls. However this is affected by the political strength of the controls and their susceptibility to variance, amendment, or political influence, including that generated from the proposed transportation project.

Where Do the Courts Stand on the Issue of Environmental Justice?

Since 1985, the concept of environmental justice has become increasingly important in indirect effects case law. The concept was formalized in 1994 in an Executive Order issued by President Clinton. Environmental justice can be defined as the right of minority populations and low-income communities to protection against disproportionately high and adverse impacts with respect to human health and environment. Proposals or decisions to site federal and state projects or actions in or near predominantly minority and low-income communities have been challenged on environmental justice grounds.

Challenges have claimed violation of the rights of protected classes of persons under the Equal Protection Clause of the Fourteenth Amendment of Constitution, 42 U.S.C. § 1983 (the Civil Rights Act of 1866), Title VI of the Civil Rights Act of 1964, and/or Title VIII of the Fair Housing Act of 1968 (Brown, 1994).

In recent years, environmental justice issues have been used in legal challenges to transportation projects. Plaintiffs have challenged proposed projects on the grounds that they will result in disparate effects on minority and/or low-income communities. Most cases deal with direct adverse impacts (**2, 32**). In these cases, the merits of the plaintiffs' disparate impact claims were not ruled on, but it is likely that environmental justice claims will begin to emerge in actions challenging transportation projects when the adverse direct and indirect effects of transportation projects impact predominately low-income and minority communities. Environmental justice litigation involving all federal program and agency action is still in the early stages of development and transportation cases involving environmental justice claims have just begun to emerge in federal case law.

SUMMARY

Although it requires that agencies take a hard look at all significant environmental impacts, NEPA demands a procedural process, not a substantive result. Agencies are required to analyze all reasonably foreseeable, significant impacts, but need not place environmental concerns above the project's positive economic development, access, safety or other benefits and goals. NEPA's focus is on disclosure, discussion and informed decision making. While direct, indirect, and cumulative effects must all be evaluated for environmental impact, the focus of the inquiry should be on the significance of any impacts, regardless of type, rather than on classification of and differentiation between primary, secondary or cumulative impacts.

Under the CEQ regulations, which are binding on federal agencies and are given substantial deference by federal courts, determination of the significance of an action requires considerations of both context and intensity. An EIS need not contemplate and evaluate every conceivable indirect impact of a proposed agency action, only those that are "reasonably foreseeable." Although uncertainty is inherent in an attempt to identify and analyze any future indirect or cumulative effect, agencies may not dodge the required analysis of future impacts by labeling such attempts mere conjecture. Instead, an EIS must engage in "reasonable forecasting" by analyzing all significant impacts that are not remote or highly speculative, but are realistically probable. As such, reasonable foreseeability means that the impact is sufficiently likely to occur that a person of ordinary prudence would take it into account in reaching a decision. An indirect impact is too speculative if it can not be described at the time the EIS is drafted with sufficient specificity to make its inclusion in an EIS useful. An environmental assessment or EIS will not violate NEPA so long as an agency acknowledges and evaluates all potential impacts that are significant and are likely enough to be identified and described with sufficient specificity—either by the agency itself or by challengers during the comment process.

Although the arbitrary and capricious standard now applies to every federal court reviewing an agency's environmental assessment and FONSI resulting in a decision not to prepare an EIS, all federal courts review the adequacy of the content of an EIS using a reasonableness standard. Under this "rule of reason" standard, the court must be satisfied that the agency has gone "beyond mere assertions" and has explicated fully its inquiry, its analysis, and its reasoning. Thus, mere listing or cataloging of possible impacts in an EIS will not pass muster under NEPA. However, the few recent indirect effects cases involving transportation projects have not required much more than a descriptive listing. Of course, the extent of detailed analysis reasonably necessary to evaluate secondary impacts depends upon the facts and circumstances of the case. Because judicial opinions do not append the administrative record and only rarely quote key or exemplary language from an EIS's evaluation of indirect effects, most published opinions provide little, if any, guidance concerning the level of detail required in an agency's analysis of the secondary impacts of transportation projects.

The relatively small number of indirect effect cases involving transportation projects provide general legal guidance for determining when a project's development-influencing effects or other indirect effects (including the environmental impacts resulting from induced residential and/or commercial growth) are significant and sufficiently probable that they must be analyzed in an EIS. Promotion of the economic benefits resulting from development-influencing impacts as "selling points" for a proposed transportation project helps establish that the indirect effects are sufficiently probable and describable to be evaluated in an EIS before the project advances to a point where it will inevitably go forward and the impacts can not be considered, reversed, or significantly mitigated.

Furthermore, no clear standards emerge from the case law regarding the use of local or regional planning documents and studies to support arguments that growth-induced development was already planned, would have occurred anyway, or that indirect effects need not be evaluated in an EIS because existing zoning and other local land use controls prohibit development of the type the project's challengers argue will be induced. The ability to rely on local plans and land use controls depends, of course, on the particular facts of the case. However, courts will consider local and regional plans and land use controls where strong arguments can be advanced that the controls will be strictly enforced and not easily subjected to variance or amendment by political influence resulting from development pressure caused, indirectly, by the proposed transportation project.

Finally, the increasing focus on environmental justice has led environmental, civil rights and community activists to begin challenging the disparate adverse environmental impacts of federal agency actions on minority and low-income communities. At present, there are very few reported cases involving environmental justice challenges to transportation projects, and those scant cases focus primarily on adverse direct impacts. In the wake of President Clinton's 1994 Environmental Justice Executive Order and related orders and strategy directives by U.S. DOT and FHWA, it is likely, however, that environmental justice claims will begin to surface more frequently in indirect effect challenges to transportation project EISs.

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COURSE MODULE **3**

STEP 1—INITIAL SCOPING FOR INDIRECT EFFECTS ANALYSIS

OVERVIEW

Scoping is the key to proper and timely identification and analysis of indirect effects. Scoping provides the best opportunity to identify potentially significant issues, set appropriate boundaries for the analysis, and identify relevant past, present, and future actions. Scoping also allows for the setting of the environmental baseline for which all effects are compared.

Scoping also provides an opportunity for interagency coordination concerning the types of indirect effects to be evaluated and methodologies to be used. The lead agency should initiate coordination with cooperating and key commenting agencies at an early stage in the scoping process.

Under the federal CEQ regulations (40 CFR 1500-1508), specific details regarding scoping are provided at § 1501.7. As part of this scoping the lead agency shall

- "Determine the scope and significant issues to be analyzed in depth in the Environmental Impact Statement" (§ 1501.7(a)(2)).
- "Identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review" (§ 1506.3).
- Narrow "the discussions of these issues in the statement to a brief presentation of why they will not have a significant effect on the human environment or providing a reference to their coverage elsewhere." (§ 1501.7(a)(3)). These issues include those that have indirect and cumulative effects as well as direct effects.

Scoping, as defined by CEQ encompasses all of the steps of the indirect effects framework that lead to the analysis of indirect effects (Steps 2 through 5), including identification of study area directions and goals, notable features, project impact-causing activities, and lastly, identification of potentially significant indirect effects. This first step of the framework is limited to initial scoping activities, assessment of effort required and identification of the study area, that set the stage for further tasks.

The intent of this module is to provide a framework for distinguishing between those projects that need detailed analysis of indirect effects and those projects that do not. Depending on the complexity of the project, scoping may need to be revisited after the completion of Steps 2 (Identification of Study Area Directions and Goals), 3 (Inventory of Notable Features) and 4 (Identification of Impact-Causing Activities).

This module will

- Outline general considerations for scoping,
- Identify the issues involved in determining general approach and level of effort required for a study,
- Provide checklists for categorization of projects and a decision tree for scoping potentially significant indirect effects, and
- Describe techniques for setting study area boundaries.

CONSIDERATIONS

Scoping should generally

- Identify the purpose and need for the project;
- Identify social, cultural, and natural (physical and ecological) resource issues that effect the human environment; and
- Identify potentially significant issues and effects for further analysis.

Full identification and consideration of these issues will be complete by the end of Step 5 of this framework. This initial step in the scoping process consists of two tasks: (1) determining the level of effort and general approach required to complete the study and (2) determining the location and extent of the study area.

Determining the General Study Approach and Level of Effort Required

At the outset of a study, it is important to determine the general approach and level of effort that will be required in an indirect effects study so that staffing, schedule, and budgetary issues may be addressed. There are several considerations involved in determining the level of effort and the general approach that will be applied. Figure 3-1 outlines factors related to the size, location, and characteristics of a project that could influence the level of effort and methodology. These factors can be summarized as follows.

Project Variables		Implication for Assessment Methodology
Project Type	Roadway	Transit and large intermodal projects often require more complex, quantitative methodologies. Sketch qualitative measures may suffice for a small roadway widening but would be insufficient for a new highway.
	Transit	
	Major Intermodal	
Project Scale	Small	Smaller projects, as measured in budget or level of complexity, are more often analyzed with qualitative methods, while larger projects are amenable to more detailed quantitative approaches.
	Medium	
	Large	
Project Scope	Local	Regional projects would require more complex quantitative methods than local projects, system planning projects may be suited to qualitative or quantitative efforts based on setting and data available.
	Regional	
	System Planning	
Stage of Study	Corridor Alternatives	Although the broad-based nature of corridor studies may be suitable for qualitative measures, quantitative models may be better for analyzing impacts in a broad area. As alternatives are described in better detail, impacts must be analyzed more thoroughly and precisely.
	Alignment Alternatives	
	Design Alternatives	
Project Setting	Degree of Urbanization	Projects in urban areas with low levels of growth may be analyzed with qualitative measures. Quantitative measures may be required in less urban areas such as suburbs or particularly the urban fringe with high levels of growth and environmental sensitivity. Rural settings where development pressure is thought to be low may require only sketch qualitative analysis.
	Level of Growth	
	Degree of Environmental Sensitivity	
Design Features	Level of Access Control	Projects with high levels of access controls (I.e. widely spaced interchanges) are likely to require a lower level of analysis since any induced development is likely to be focused at access points. Similarly, projects that do not provide additional capacity are unlikely to change accessibility and therefore require a lower level of analysis, that can be qualitative in nature.
	Degree of Capacity Added	
Project Purpose	Relieve Congestion	Projects designed only to relieve congestion may not need extensive analysis if they do not significantly change local or regional accessibility. Projects planned to serve existing development require a detailed assessment of the effects of that development. Projects intended to promote regional development must describe the nature and effects of that development.
	Serve Existing/Planned Development	
	Promote Regional Economic Development	
Data Available	Level of Quantification	Overall, the type of data available may have more influence on approach than other factors. Some of the more complex quantitative methods require detailed parcel level data in computer readable form, information not available in all cases.
	Level of Aggregation	
	Comprehensiveness	
	Currency	

Figure 3-1. Factors to consider when matching methodologies to project types.

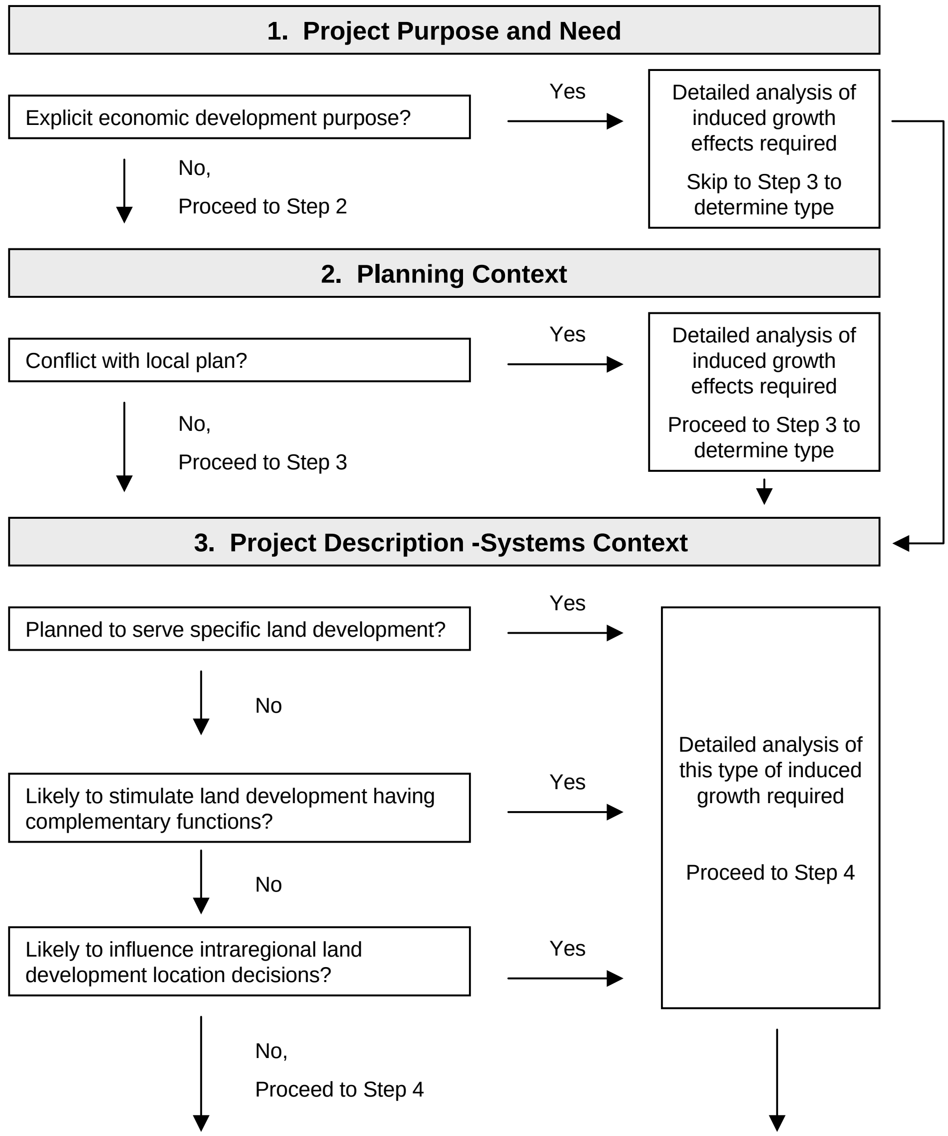

Figure 3-2. Decision tree for scoping potentially significant indirect effects and cumulative effects requiring detailed analysis. (*Continued on next page*).

Data Availability—Steps 2 through 4 of the framework require data related to study area goals and trends, notable features and project activities. Typically, much of the data needed for the indirect effects assessment will have been collected or developed for other purposes (e.g., project purpose and need, market feasibility, direct effects, permit applications). On some occasions, however, extensive original data collection will be needed to complete these steps where such information is not readily available.

Number of Potentially Significant Impacts—One of the intents of NEPA is to focus impact assessment on impacts that are considered potentially significant. The number of potentially significant impacts affects the level of effort associated with Step 5, Identify Potentially Significant Indirect Effects (and concomitant cause-affect relationships). This variable also effects Step No. 8, Assess the Consequences of the Indirect Effects (and develop mitigation and enchancement where appropriate). A decision tree for determining the number and type of indirect effects that can be anticipated is presented in Figure 3-2 (see discussion below).

Appropriate Technique—Steps 6 and 7 relate to analyzing the magnitude of the potentially significant effects. Detailed qualitative or simple quantitative techniques typically satisfy analysis requirements regardless of potential impact significance. Under certain circumstances, however, a detailed quantitative technique, for example, travel demand or land use forecasting, is needed to improve precision to a finer level of detail.

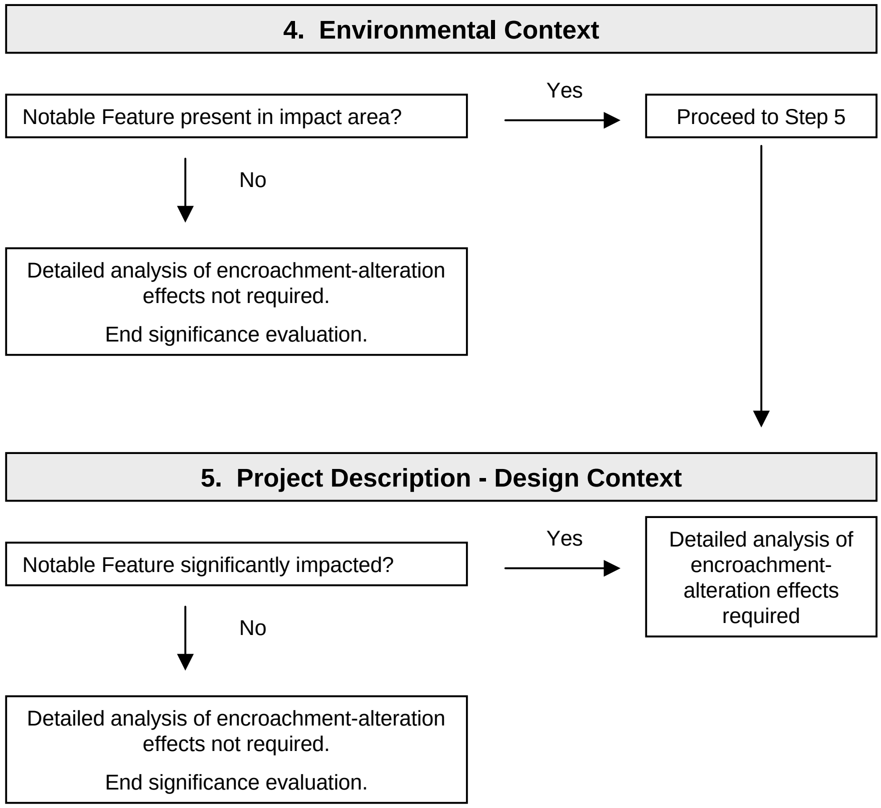

Figure 3-2. (Continued).

Extensiveness of Effect—The findings indicate that the spatial effect is primarily a function of project type and maturity of the regional transportation system and land development. Greater effects are associated with new facilities relative to expansion of existing facilities. Further, linear projects (e.g., new highways or fixed transit guideways) typically have the most extensive effects when compared with new interchanges, transit stations, or bridges, or with new ports, airports and related facilities.

Because general guidelines are often difficult to apply to a unique set of project circumstances, analysts may find it more useful to make an initial attempt at gauging the number and type of indirect effects that may require study. Figure 3-2 provides a decision tree designed for this purpose. In this initial stage of scoping, questions should be answered as completely as possible with the information at hand. Subsequent steps in the indirect effects assessment process outline techniques and data requirements for a complete assessment. Considerations outlined in the decision tree and useful in this initial scoping step are discussed in more detail below.

Project Purpose and Need

The importance of establishing a well thought out purpose and need statement for transportation projects is addressed in upcoming FTA and FHWA NEPA guidance. Economic development (from induced growth) is often cited as justification for proposed transportation projects. Indeed, certain programs (e.g., "development highways") are authorized by legislation with economic development as their intent. With respect to indirect and cumulative impact assessment, the questions of confidence in and specificity of types of induced growth or secondary impacts as set forth in various court decisions can often be condensed into a single question: if the benefits of induced growth are "selling points" of the project, including those that are legislated, an environmental assessment/EIS must consider them. Ignoring selling points in an environmental assessment/EIS can lead to segmentation and a judicial finding of inadequacy. In other words, addressing the virtues of induced growth while ignoring its disadvantages is certainly not the "environmental full disclosure" required by NEPA.

Among the potential externalities of project-influenced growth are increased population, increased traffic, increased pollution, and increased demands for services such as utilities, education, police and fire protection, and recreational facilities. If a project's justification depends in whole or part on marketing induced growth or other project-generated benefits to the area (e.g., access to a major activity center) then there is no question that such effects are "reasonably foreseeable" and must be included in the NEPA document.

Planning Context

Consistency with local plans is one of the project evaluation criteria for NEPA. Potential inconsistency between a project's indirect effects and planned development patterns expressed in adopted plans (as well as zoning adopted to enforce the plans) is a potentially significant issue for the project's evaluation. In addition, the project's cumulative impact assessment needs to account for planned future development as expressed by any relevant adopted plans. In addressing indirect and cumulative impact assessments as part of environmental impact statements, courts have found that current and contemplated plans of private parties and local government outside the direct control of state and federal government must be reviewed. Based upon that review, reasonable forecasting of the type of development must be conducted.

Social, economic, and environmental goals expressed through formal plans reflect a current vision of a desired future. Because of their inherent rippling effect over space and time, one way to measure a transportation system's or project's indirect effects is to envision the future both with and without the system or project improvements. Consideration of various goals early in the planning process can help focus the effort toward balancing transportation and other needs, and also toward understanding potential indirect (and cumulative) effects.

Empirical evidence indicates that transportation investment and changes in land use occur only in the presence of other factors, such as supportive local land use policies and development incentives, availability of developable land, and a good investment climate. Therefore, an understanding of local goals combined with an understanding of the role that a transportation investment could play in achieving these goals, given local circumstances, could lead to the coordinated formulation of a broad range of actions for reaching these goals. Ideally, the desired future or outcome should lead, and the transportation solution combined with other appropriate strategies (e.g., land use, environmental protection, and housing) should follow.

As discussed above, proposed transportation improvements are often planned to support an area's economic development goals. In this case, the anticipated economic growth and land use conversion from that growth are to be treated as indirect effects of the transportation project. Understanding the economic development goals should not only help formulate the scope of the proposed transportation improvement, but will also help eventually understand the nature of the induced indirect effects.

Project Description—Transportation System Context

As discussed above, projects with an explicit economic development purpose or projects designed to serve specific land development will, by definition, result in indirect effects that require analysis. To the extent to which these plans are known at the outset of a study, analysts can determine the level of effort and general methodology based on information regarding location and magnitude of development plans.

A second type of induced growth to be considered in scoping is land development that is complementary to the project (see more detailed discussion in Module 7). This type of development includes highway-oriented businesses such as gas stations, restaurants, and hotels that open in the vicinity of new interchanges in rural areas. This type of growth is not likely to be seen in more developed suburban areas or in situations where a new interchange is added in proximity to other areas where complementary development is already established. Complementary development can also be seen in developed urban area businesses such as newsstands, delicatessens, and dry cleaners, which serve transit riders attracted by new or expanded transit stops.

A third type of induced growth relevant to scoping is a change in intraregional land development decisions (see more detailed discussion in Module 7). Transportation projects that produce a significant change in accessibility between major nodes of employment, housing, and commercial development can make an area more attractive to development. Basic information regarding a project's propensity to change accessibility can help analysts gauge whether this affect merits investigation. Changes in accessibility imply changes in travel demand and travel patterns. Modeling of travel demand in transportation systems has been common practice for decades, and is required by federal regulations in urbanized areas. In modeling practice, a project (or change in the system) needs to be of a certain size to produce a measurable change in travel demand or travel patterns. Therefore, it follows that only those projects that could produce a measurable change in travel demand or travel patterns (and, thus, accessibility) need to be examined for indirect and cumulative effects in the transportation system context (regardless of whether the project is in an urbanized area or a rural area). Figure 3-3 provides a checklist for categorizing new highway construction projects on the basis of system characteristics. Figure 3-4 lists transportation project types that potentially change local and regional accessibility.

Environmental Context

Indirect effects related to encroachment-alteration are another consideration in scoping. These effects can be related to project impact causing activities or can arise from induced growth. This type of effect is only possible, however, if notable environmental features are present in the study area. These features (discussed in detail in Module 5) include aspects of the ecological, social, and physical environments valued in the study area. Although a full inventory of notable features will be conducted in Step 3 of the indirect effects assessment process, knowledge of the location and extent of the more impor-

1. Type of new construction:

a. Bypass: _____ yes _____ no
b. Connector Road: _____ yes _____ no
c. Roadway Relocation: _____ yes _____ no
d. New Highway Construction: _____ yes _____ no
e. New Interchange Construction: _____ yes _____ no
f. Others: _____ yes _____ no describe: __________

Please answer questions 2 and 3 relating to current conditions on the primary existing route. If a model is used, please provide node numbers.

2. Road Section Description:

a. Name (SR Route): ___________
b. From: ______________________ Node # _________
c. To: ________________________ Node # _________
d. Segment Length: ____________
e. Function Class (Check one):
___ Rural Interstate ___ Other Princ. Art. ___ Minor Art.
___ Major Collector ___ Minor Collector ___ Local
___ Urban Interstate ___ Other Freeway ___ Other Princ. Art.
___ Minor Art. ___ Major Collector ___ Local
f. Area Type (check one) ___ Rural ___ Small Urban ___ Urban

3. Traffic Data:

a. Annual Average Daily Traffic (AADT) Volume: _________ veh/day
The above traffic count is (check one): _____ One-way _____ Two-way

b. Average Weekday Daily Traffic (ADWT) in July: _________ veh/day
c. The above traffic count is (check one): _____ One-way _____ Two-way

Please answer questions 4 and 5 concerning the new alignment. If a model is used, please provide node numbers.

Figure 3-3. Characterization of new highway construction. (*Continued on next page*).

tant features will aid in assessing the level of effort and general approach required by the study. Complex projects with a high potential for induced growth or a complex array of impact-causing activities (discussed in detail in Module 6) are more likely to require detailed analysis for encroachment-alteration effects.

Determining the Location and Extent of the Study Area

Once information available at the outset of the study has been used to plan the general approach, it is appropriate to set boundaries for the analysis in time and space. This section will outline the primary alternatives available to analysts.

When estimating the direct effects of a proposed project, study areas are often delineated using a set distance from the centerline or right-of-way. Because indirect effects can occur at a distance in time or space from the proposed project, broader limits, often not a uniform distance from the proposed project, must be set. Techniques for determining study areas fall into the general categories discussed below.

Political/Geographic Boundaries

Study area boundaries based on the limits of political jurisdictions or geographic features often work to facilitate analysis for the following reasons:

4. New Road Description:

a. Name (SR Route): ___________

b. From: _____________________ Node # _________

c. To: _______________________ Node # _________

d. Segment Length: ____________

e. Function Class (Check one):

___ Rural Interstate ___ Other Princ. Art. ___ Minor Art.

___ Major Collector ___ Minor Collector ___ Local

___ Urban Interstate ___ Other Freeway ___ Other Princ. Art.
___ Minor Art. ___ Major Collector ___ Local

f. Area Type (check one) ___ Rural ___ Small Urban ___ Urban

5. Traffic Forecast (not needed for model):

a. New alignment volume: Estimated average daily traffic: ______ veh/day
The above traffic estimate is (check one): _____ One-way _____ Two-way

b. Estimated Peak Hour Diversion from Parallel Facilities:

i. From Freeways:

From Street: ______________________________ Volume (vph) ___________

To Street: ______________________________

From Street: ______________________________ Volume (vph) ___________
To Street: ______________________________

From Street: ______________________________ Volume (vph) ___________

To Street: ______________________________

ii. From Arterials:

From Street: ______________________________ Volume (vph) ___________

To Street: ______________________________

From Street: ______________________________ Volume (vph) ___________
To Street: ______________________________

From Street: ______________________________ Volume (vph) ___________

To Street: ______________________________

iii. From Locals:

From Street: ______________________________ Volume (vph) ___________

To Street: ______________________________

From Street: ______________________________ Volume (vph) ___________
To Street: ______________________________

From Street: ______________________________ Volume (vph) ___________

To Street: ______________________________

Figure 3-3. (Continued).

1) Highway/Roadway

   a) New construction or new alignment. Principal Arterial or above, 1 mile or longer;

   b) Widening of Principal Arterial or above to provide additional through-traffic lanes, 1 mile or longer (urban) or 2.5 miles or longer (rural);

   c) Additional grade-separated ramps or new interchanges on Principal Arterials or above.

2) Traffic Signals

   a) Coordination and upgrade of signal systems on Principal Arterial or above, encompassing at least 10 signals (urban) or 5 signals (rural) and at least 2.5 miles of state highway (urban) or 5 miles (rural).

3) Transit/Rail

   a) New passenger rail service and extensions of existing service, 5 miles or longer;

   b) Purchase of additional (not replacement) rolling stock to support increased frequency and higher ridership;

   c) Rail connections to provide new regional service;

   d) New rail stations and new or expanded rail park-and-ride facilities resulting in 100 new parking spaces.

Figure 3-4. Examples of minimum projects which potentially change local or regional accessibility.

- Many existing data sources such as demographics, growth projections, comprehensive plans, and resource inventories are delineated by political jurisdictions;
- Stakeholders and the public can easily understand familiar political or geographic boundaries; and
- Land use regulations and other measures to curb induced growth effects are enacted on the county or municipal level.

Examples of political or geographic boundaries include the following:

- Counties,
- Minor civil divisions (municipalities),
- Tribal lands,
- Planning districts,
- Special improvement districts and enterprise zones,
- Census tracts or block groups,
- Traffic analysis zones or aggregations of zones, and
- Rivers, water bodies, mountain ranges.

While using political or geographic boundaries can make the task of gathering data and presenting findings easier, care should be taken to avoid the following errors:

- *Undersized study area*–Dividing lines between political jurisdictions are often arbitrary and do not reflect present or future trends in development. Similarly, habitat areas or areas of social cohesion may cross these dividing lines. Thus, this method may be most appropriate after an examination of community characteristics, commute patterns, growth trends, or habitat locations using the methods below. The study area can then be increased in size to match the boundaries of a political jurisdiction or group of jurisdictions that encompass important features. The choice of a study area along political or geographic boundaries should always be done so as to increase the size of the study area.
- *Oversized study area*–While an oversized study area is preferable to a smaller one, a larger study area will require a greater commitment to data gathering and analysis. A larger study area also may increase the threshold for consideration of when environmental features can be considered notable. This may cause impacts on smaller community or habitat features to be overlooked.

Commuteshed

Effects related to project-influenced development depend on changes in accessibility. Projects that have the potential to substantially alter travel times to major regional demand generators may make an area more attractive to growth and development. To fully account for this effect, a study area should be sized to coincide with a set commuting range or travel time to a major destination. Destinations should be of a size and type sufficient to affect the locational choices of future residents or employers and include city centers, or major regional employment centers such as office or industrial parks, or suburban commercial centers.

Commuteshed boundaries can be determined through several techniques:

- *Census data* can be used to set the commuting time threshold. For example, most commutes in many parts of the nation are 20 to 30 min in duration. The journey-to-work questions on the Decennial Census provide information on the range of commute times in a county, municipality, or census tract by mode of transportation. The 1990 Census Transportation Planning package available from the Bureau of Transportation Statistics (U.S. DOT) provides characteristics of workers, of persons, workers, and housing units at the Traffic Analysis Zone (TAZ) level. For projects of regional significance or transportation systems planning, journey-to-work county flow files available at the Census internet site show county of origin by place of work or county of employment by place of residence.
- *Origin and destination surveys* conducted by a regional planning agency, or for study of the need for proposed project or other projects in the study can be used to delineate a study area by grouping together the most frequent pairings of origins and destinations.
- *Travel demand model output* can also be used to delineate a study area based on flows between TAZs.

When using the commute threshold technique, the study area should whenever possible take the travel time savings of the project alternatives into account. This can be accomplished by setting the study area to coincide with the area accessible under the alternative that provides the greatest time savings. Similarly, output from a travel demand model of the alternative with the most time savings would be appropriate. Origin and destination surveys are not dynamic and so may not be practical in situations where there is a great difference in travel time between the no-build and the various build scenarios.

Growth Boundaries

In jurisdictions with growth management policies, areas suitable for development or areas expected to see growth in population or employment may already have been delineated in long-range infrastructure (sewer/water districts) or growth management plans. In some cases, development beyond this area, or the extension of infrastructure to serve it, is limited or restricted. In these circumstances, it may be appropriate to confine consideration of indirect effects to a study area coincident with accepted growth boundaries. When doing so, efforts should be made to evaluate the effectiveness or strength of the growth regulations to confirm that development beyond the proscribed area is indeed unlikely. It should also be confirmed that no encroachment alteration effects arising from the project could occur outside this growth boundary study area.

Watershed/Habitat

Encroachment-alteration effects arising from a project or project-influenced growth may have immediate effects on a watershed or habitat that give rise to broader ecosystem, water quality, or water quantity issues. To anticipate the full range of effects, it may be appropriate to size the study area to match the extent of potentially impacted watersheds or habitat features. This can be accomplished through a baseline screening of notable features of the natural environment (see Step 3, Module 5).

Interview/Public Involvement

Stakeholder interviews, expert panel techniques, task forces, or other public involvement efforts can be used to define a study area, or approve or refine a study area created with any of the techniques described here. The general approach is to query experts or stakeholders about the geographic extent of potential effects or test the validity of findings derived from another technique.

Timeframe Considerations

Since indirect effects can be distant from the project in both time and space, setting a time for the analysis is another goal of scoping. The time frame should be short enough in duration to anticipate reasonably foreseeable events, but should be long enough in duration to capture the development and relocation effects that may only transpire over the course of several business cycles. Most indirect effects study set a time horizon equal to the design life of a project usually 20 to 25 years. This is also the time horizon used in most MPO- and county-level planning forecasts.

Combining Study Area Tools

As suggested in the discussion of study area techniques above, these tools can be combined to produce a study area suitable for consideration of the full range of potential indirect effects. For example

- A commuteshed or growth boundary technique could be used to define the area for consideration of induced growth effects.
- Then a habitat or watershed approach could be added to ensure consideration of encroachment-alteration effects or environmental effects related to induced growth.
- To facilitate data gathering, the size of this combined study area may be increased to encompass an entire political or data unit or groupings of those units, (e.g., counties, municipalities, or groupings of TAZs).
- The delineated study area and the methods used could then be presented to a task force to seek their concurrence.

WORK PRODUCT OF STEP 1

The work product for the initial scoping effort should consist of a detailed work plan or technical memorandum outlining the methodology for the analysis. In addition, a map delineating the study area boundaries should be produced along with a description of the methods employed in study area determination.

COURSE MODULE **4**

STEP 2—IDENTIFY STUDY AREA DIRECTIONS AND GOALS

OVERVIEW

After scoping and delineation of the study area are complete, it is important to gather a wide range of data about the study area. This second step in the indirect effects assessment framework will focus on assembling information regarding general trends and goals within the study area. The trends and goals in question are independent of the proposed transportation project and typically concern social, economic, ecological, and/or growth-related issues.

Empirical evidence indicates that transportation investments result in major land use changes only in the presence of other factors. These factors include supportive local land use policies, local development incentives, availability of developable land, and a good investment climate.

An understanding, therefore, of community goals, combined with a thorough knowledge of demographic, economic, social, and ecological trends is essential in understanding the dynamics of project-influenced changes in development location. Later in the process, it will also be important to compare study area goals with potential impacts. Conflict between impacts and goals is a key determinant of impact significance and an indicator of effects that merit further analysis. Knowledge of goals and trends will also facilitate an evaluation of project alternatives and the formulation of strategies to meet all community and regional goals.

There are a variety of considerations related to identification of study area trends and goals. This module will provide practitioners with an overview of these considerations and will (1) outline the types of goals and trends relevant to this step, (2) highlight potential sources of information, (3) describe techniques for data gathering and public involvement, and (4) provide checklists useful for applying this step in practice.

CONSIDERATIONS

Timing

Ideally, this step should be timed to coincide with the process of problem identification and needs assessment, the first step in the transportation planning and development process. Conducting this step during the earliest part of the planning process for transportation systems or projects will help to ensure that the social, economic, and environmental goals of communities in the study areas will be evaluated in tandem with their transportation needs in formulating proposals for transportation projects. It will also facilitate a streamlined NEPA process, promote the minimization of conflict between project effects and study area goals, and work to reduce the need for mitigation and enhancement efforts after the project has been designed.

Because trends and goals are subject to change over time, and the length of time between the planning process and NEPA evaluation can be lengthy, it will be important to reevaluate the currency of any data throughout the NEPA process.

Analysts beginning the process of indirect effects analysis after the project has been designed should make every effort to use information developed previously to assess project purpose and need. Evaluations conducted for statewide planning purposes or transportation plans developed by MPOs may also be useful.

Social, economic, and environmental goals expressed through formal plans reflect a current vision of the future. Because of their inherent rippling effect over space and time, one way to measure a transportation system's or project's indirect effects is to envision the future both with and without the system or project improvements. Consideration of various goals early in the planning process can help focus the effort toward balancing transportation and other needs, and also toward understanding potential indirect (and cumulative) effects.

Data Collection

Goals are typically spelled out in plans or policies. The content of available plans is typically examined during the transportation project development process. For example, such plans can provide future population and employment growth and land development information for the study area. Further, the CEQ NEPA regulation (40 CFR 1508) requires an evaluation of project consistency with local plans. The literature indicates that better understanding of the interrelationships between an area's transportation and other goals early in the process can lead to better anticipation of a proposed transportation project's indirect effects issues (e.g., a balance between conflicting needs and goals). However, this does not mean that conflicts over indirect effects will necessarily be avoided by considering non-transportation goals in the process.

CEQ has outlined general goals (11 principles) of ecosystem (biodiversity) management (Figure 4-1). CEQ suggests that these goals be considered by federal agencies when assessing the effects (direct, indirect, and cumulative) of their actions, including actions at the project-specific or site-specific levels. These goals have been expressed through a number of federal, state, and local resource management plans (e.g., those for the Chesapeake Bay and Great Lakes watersheds).

Relative to ecological goals, social or economic goals are typically not as well formulated or articulated at this time, both generally and at the local level. While general principles of social impact assessment are being advanced, goals are typically expressed in very broad terms and will vary by location.

Proposed transportation improvements are often planned to support an area's economic development goals. In this case, the anticipated economic growth and land use conversion from that growth must be treated as indirect effects of the transportation project. Understanding the economic development goals should not only help formulate the scope of the proposed transportation improvement, but will also help eventually understand the nature of the induced indirect effects.

While it is recommended that available plans be used to help determine the area's various goals, several items should be kept in mind:

Age of the Plan—In many areas, there is no requirement for periodic updating of comprehensive plans even where there is a formal planning process. Political winds tend to change over time, and a dated plan may not reflect the area's current needs and goals.

Geographic Coverage of the Plan—Often, an incorporated area may have a comprehensive plan and zoning while an adjoining unincorporated area does not. The distinction between the incorporated and unincorporated area in terms of current land use may not be clear. However, the absence of land use controls in the unincorporated area may affect the character of future urbanization in the incorporated area. In addition, one municipality's growth management plan may not conform to the overall plan for a region.

Plan Preparers—It is important to know who was involved in plan preparation, for example, whether or not the local citizenry has bought into a resources management plan prepared by a non-local entity.

Importance Ascribed to Plan—The degree of importance attached to the goals by the public and their decision-making authorities is important in determining any potential conflict between goals and impacts and in gauging the likelihood of plan enforcement or change in the future.

Even in areas where there is an up-to-date plan and an effective planning process, it is probably wise to use a public involvement method or methods to at least confirm the directions and goals expressed in the plan, plus to gather information on the area's directions and goals first hand, when appropriate. Moreover, certain methods can be used to flesh out alternative scenarios in more detail than expressed in a plan. This greater level of detail may be needed for subsequent indirect effects assessment if issues are anticipated. Accordingly, the methods discussion evaluates appropriate public involvement techniques for this step.

1. Take a "big picture" or ecosystem view;
2. Protect communities and ecosystems;
3. Minimize fragmentation, promote the natural pattern and connectivity of habitat;
4. Promote native species, avoid introducing non-native species;
5. Protect rare and ecologically important species;
6. Protect unique or sensitive environments;
7. Maintain or mimic natural ecosystem processes;
8. Maintain or mimic naturally occurring structural diversity;
9. Protect genetic diversity;
10. Restore ecosystems, communities and species.
11. Monitor for biodiversity impacts, acknowledge uncertainty, and be flexible.

Figure 4-1. CEQ goals for ecosystem (biodiversity) management (source: CEQ, Incorporating Biodiversity Considerations into Environmental Analysis Under the National Environmental Policy Act, January, 1993).

The area's expressed goals give a part of the picture needed to understand potential indirect effects in a "big picture" context. It is also important to understand direction, that is, where an area has been, where it is, and where it is going. Direction can be understood in part by identifying past, present, and anticipated socioeconomic, environmental quality, and land development trends. Equally important is knowing the forces that have shaped landscapes, economic activity, and land use patterns (e.g., transportation system, physical environment, political, and market influences, and how the forces have been influential [the same is true of existing and anticipated forces]).

METHODS

Step 2A—Data Collection

The data collection task for this step should generally rely on readily attainable sources. The data collection should not be viewed as an end in and of itself, but rather as a foundation for future steps. Data for this purpose can be both quantitative and qualitative. Figure 4-2 describes potential sources of data regarding plans and trends. The checklists provided in Figures 4-3 and 4-4 are for use in identifying, organizing, and documenting directions and goals.

Local/Regional Trend Data	
U.S. Census Data	Recent and historical data on population and household growth, race and ethnicity, income, age, and other important factors can be obtained from the U.S. Census Bureau and assembled in time-series for tracts, block groups, or other geographic areas making up the study area to reveal trends.
State/Regional Growth Forecasts	State planning agencies, MPOs or other regional planning authorities are often responsible for generating 20-year growth forecasts for areas under their jurisdiction. Official forecasts of this type should be utilized whenever possible.
County Business Patterns	Data and analysis on industry and economic trends assembled for counties and groups of counties are available through the U.S. Census Bureau.
BEA Industry Data	The U.S. Bureau of Economic Analysis (Department of Commerce) maintains time-series data on industry earnings and employment at the county or MSA level. This data can reveal important trends regarding the character of economic development in the study area.
County/Local Building Permit Data	Yearly data on issuance of building permits or certificates of occupancy can be obtained from county or local authorities to reveal trends on household growth and location.
Variance/Zoning Change History	Public records of county or local authorities with responsibility for granting zoning variances or adopting changes to zoning regulations can be consulted to identify trends in the enforcement and stability of land use regulations.
Land Use Plans/Comprehensive Plans	
State and Regional Land Use Plans	In some jurisdictions state or regional authorities develop general land use plans containing recommendations or regulations on conservation areas and areas for residential, commercial, and industrial development.
County Land Use Plans	In some jurisdictions county agencies are responsible for land use plans for the county as a whole or unincorporated areas. The plan may identify goals and objectives for the future physical development of the county with respect to public and private uses of land or other natural resources with an aim of enhancement of physical and economic conditions.
Local Land Use and Master Plans	Where local land use and master planning is conducted, plans should be examined for descriptions of goals and anticipated future conditions.

Figure 4-2. Description of data sources for identification of goals and trends (Adapted in part from: Indirect and Cumulative Effects Analysis for Project-Induced Land Development, Wisconsin DOT, 1996). (*Continued on next page*).

Federal, Tribal, or State-owned Property Master Plans	Where study areas contain federal or state owned lands, care should be taken to examine plans for the use and expansion of parks, wildlife areas, refuges, forests, and prisons. Development plans for tribal areas are also important.
Park and Open Space Plans	Counties, towns, and cities may make plans for parks and other open spaces and the management of this land for public enjoyment. The plan can serve to refine and detail the park and environmental corridor preservation recommendations set forth in state or regional plans.
Farmland Preservation Plans	In some jurisdictions special plans regarding development and conservation of farmland areas have been enacted.
Sewer/Water Service Area Plans	In some jurisdictions special plans have been developed to guide future expansion of sewer and water utility services. Provision of these services is often directly correlated with the potential for higher density development.
Studies Done by Regional Planning Commissions	Mops or regional planning commission may have conducted studies or may maintain databases of information regarding land use plans, regulations, and trends.
Local Area Development/Redevelopment Plans	In many jurisdictions, municipalities are authorized to prepare redevelopment plans for areas that substandard or unsanitary as a result of inadequate planning, excessive land coverage, lack of proper light, air, and open space, or other problems of age, or physical deterioration.
Economic Development Agency Plans	Relevant state, regional, or local economic development agencies should be consulted for information regarding areas targeted for development, future development incentives or other plans.
Private Sector Plans	Large private-sector land holders, such as corporations, developers, private universities, or nature conservancies, may produce plans for the development or management of their land holdings.
Transportation Corridor Plans	An integrated transportation and land use plan may have been prepared for other critical transportation corridors in the study area that have high development potential.
Other Environmental Documentation	Environmental documentation conducted recently for other facilities or projects within the study area may be consulted for data or leads for data sources.
Local /Regional Development Regulations	
County/Local Zoning Ordinances	Zoning is an exercise of government power that regulates and restricts the use of private property in the public interest. Data on zoning area boundaries and regulations are important for determination of goals and application of further analysis techniques.
Official Maps	Official maps illustrate government boundaries, zoning districts, government lands, and street and highway facilities. Maps, particularly those in digital form are useful for overlay analysis techniques.
Growth Boundaries	In jurisdictions that have enacted urban growth boundaries, it is important to obtain detailed information regarding boundary locations, regulations, and future plans.
Annexation/Extraterritorial Zoning	In jurisdictions where incorporated areas are allowed to exercise zoning authority or annex areas outside their boundaries, information should be gathered on regulations and future plans.
Coastal Regulations	Development and use of coastal areas, floodplains, and wetlands are often regulated by special statutes.
Local Highway Access Controls	Access controls on local roadways within the study area but outside the project area such as curb-cut regulations or arterial access controls are relevant in analysis of goals and future development potential

Figure 4-2. (Continued).

Special Development Districts	Some jurisdictions may have special districts that regulate development. Examples include urban redevelopment areas, business improvement districts, planned unit development districts, tax increment finance districts, and historic preservation districts.
TDR Sending/Receiving Zones	Some jurisdictions have enacted regulations regarding the transfer of development rights from restricted properties to properties where development is encouraged.
Inclusionary Housing Incentives	Some jurisdictions have enacted regulations and incentives to encourage the development of low-income housing.
Easements and Deed Restrictions	Easements and deed restrictions may determine the future developability of a land parcel. Conservation easements, restricting future development regardless of ownership, have been used recently with more frequency.
Development Moratoria	As part of the zoning authority in some jurisdictions, municipalities or counties may declare a moratorium on development for a fixed or limited time to allow for the completion of infrastructure or land use regulations.
Impact Fees	Some jurisdictions have imposed impact fees on developers to pay for government capital costs necessary to serve development.

Figure 4-2. (Continued).

There are three general sources of data to be considered for this step:

1. *Local/Regional Trend Data*—Recent and historical demographic data available from the U.S. Census Bureau can be assembled in time series and used to identify trends in population and household growth, location, and composition. Official projections generated by state, regional, or MPO agencies should also be used whenever possible as a source of information on future conditions. Profiles on trends in industry and the regional economy can be generated from Census Bureau data (*County Business Patterns*) or other government sources (Bureau of Economic Affairs). Data from local authorities regarding annual building permit statistics and zoning variances or changes may also be useful in identifying development trends.
2. *Land Use Plans/Comprehensive Plans*—A variety of public and private entities may be responsible for generating plans reflecting land use and community goals in the study area. The full range of local and regional master plans, park and open space plans, infrastructure plans, and economic development agency documents should be compiled and carefully examined to gather information on the economic, social, and land use goals of communities in the study area.
3. *Local/Regional Development Regulations*—Development regulations currently in force in the study area can be useful in determining community goals and isolating potential areas of conflict as project impacts are identified. Zoning ordinances, special district regulations, and development incentives/disincentives should be examined carefully. Maps of the development regulation boundaries, especially digitized shapefiles for use in geographic information systems (GIS), may be useful in other aspects of indirect effects analysis.

Step 2B—Public Involvement

Of course, it is important to deal with facts, particularly when facts are readily obtained. However, facts tell only part of the story (or do not exist for all items of interest). Perceptions of directions and goals or opinions about them can be valuable in establishing a "big picture" context.

A number of public-involvement techniques are advocated for obtaining the perceptions or opinions. For example, the U.S. DOT document, *Innovations in Public Involvement for Transportation Planning* (1994), is a notebook that outlines various practical techniques of public involvement that can be used in a variety of situations. The reader should consult these and other pertinent documents for details. A comparison of techniques relevant to goals development includes the following:

- *Visioning*—This technique typically consists of a series of meetings focused on long-range issues. It looks for common ground among participants in exploring and advocating strategies for the future. With overall goals in view, it avoids piecemeal and reactionary approaches to addressing problems. It accounts for the relationship between issues, and how one problem's solution may generate

(Check where applicable)

Project Name: ___________________ Location: _____________ Analyst: ____________ Date: _________

	Notes
Social Health and Well-Being Goals	
___ Achieve adequate, appropriate and accessible open space and recreation	______________________
___ Comply with state and federal water and air quality laws	______________________
___ Preserve or create multicultural diversity	______________________
___ Preserve heritage	______________________
___ Provide choice of affordable residential locations	______________________
___ Provide urban environment for those with special needs	______________________
___ Promote land use patterns with sense of community	______________________
___ Provide a range of services accessible to all	______________________
___ Promote a healthy and safe environment	______________________
___ Provide sound management of solid and hazardous waste	______________________
___ Other ____________________	______________________
Economic Opportunity Goals	
___ Support activities to meet changing economic conditions	______________________
___ Provide energy-efficient transportation	______________________
___ Provide developments with transit-supported capabilities	______________________
___ Target economic export activities	______________________
___ Attract and maintain workforce	______________________
___ Promote infill of smaller, passed-over sites	______________________
___ Encourage redevelopment of older areas for new purposes	______________________
___ Other ____________________	______________________
Ecosystem Protection Goals	
___ Protect ecosystems	______________________
___ Minimize fragmentation	______________________
___ Promote native species	______________________
___ Protect rare and keystone species	______________________
___ Protect sensitive environments	______________________
___ Maintain natural processes	______________________
___ Maintain natural structural diversity	______________________
___ Protect genetic diversity	______________________
___ Restore modified ecosystems	______________________
___ Other ____________________	______________________

	Name	Affiliation	Date
Reviewed by:			

Figure 4-3. Organization and tabulation of goals chart.

Project Name: ________________ Location: ____________ Analyst: ___________ Date: ________

1. **Generalized Setting**
   Within Metropolitan Statistical Area (Identify MSA) ____
   Outside of MSA ____
   Both Inside and Outside MSA ____ Indicate Distance to Nearest Metropolitan Center ____

2. **Characteristics of Transportation System** (Note: These items are not intended to cover entire transportation need but rather to use information from more detailed assessments to provide a preliminary indication of existing accessibility, service and modal interrelationship characteristics, i.e., factors relevant to subsequent indirect effects analysis).

- Identify missing links in transportation system _______________.
- Map and describe existing level of service on minor and principal arterials and their access characteristics.
- Indicate distance to nearest interstate highway if not in study area.
- Map and describe existing transit routes and demand.
- Map and describe major concentrations of existing and planned development.
- Describe modal interrelationships including competing and complementary characteristics.

3\.

Population	Trend	Projection
Declining	___	___
Static (±1%/10 years)	___	___
Slow Growth	___	___
Rapid Growth (>10%/10 years) ___		___

Employment	Trend	Projection
Declining	___	___
Static (±1%/10 years)	___	___
Slow Growth	___	___
Rapid Growth (>10%/10 years) ___		___

4\. **Planning Context**

	Yes	No	If yes, identify by title, agency and date
Zoning	___	___	___________________
State Master Plan	___	___	___________________
County/Regional Master Plan	___	___	___________________
Municipal Master Plan	___	___	___________________
Growth Management Plan	___	___	___________________
Water Quality Management Plan	___	___	___________________
Other Natural Resources Management Plan	___	___	___________________

5. **For each plan identified in No. 3, summarize key goals, elements and linkages to other plans (specify, in particular, elements related to economic development, land use development, the transportation system, and natural resource protection).** ______________________________

6. **Describe any efforts to elicit local needs and goals from residents and/or agencies (source and result).** ______________________________

7. **Describe known plans for major new or expanded activity centers including public facilities.** ______________________________

   Is the activity center dependent on transportation system improvement? Yes ____ No ____

8. **Is the transportation need linked to economic growth and land development?** Yes ____ No ____
   If yes, is the nature of the linkage to:
   Serve the needs of planned growth _____ or
   Channelize growth _____ or
   Stimulate growth _____ or

9. **Based on information obtained, are there any apparent conflicts between transportation and other needs that could result in controversy? (Describe).**

   Yes _____ Possible _____ No

Reviewed by: Name Affiliation Date

Figure 4-4. Study area directions and goals checklist.

other problems (e.g., indirect effects). To be balanced, visioning requires involvement of all stakeholders, and a cross-section of citizens. Resources required for visioning typically include a staff leader committed to the process, a community participation specialist who is well versed in the applicable subject matter, and staffers who can interpret and integrate participants' opinions from surveys and meetings. If forecasts of information are developed or if alternative scenarios are to be fleshed out, research and preparation time can be extensive.

- *Citizen survey*—This technique is used to assess widespread public opinion through a survey administered to a sample group of citizens via a written questionnaire or through interviews in person, by phone, or by electronic media. Surveys can be used to obtain information for determining residents' perceptions of an area's future directions and goals. Surveys can be informal or formal (scientific) with formal surveys being more expensive and requiring a higher level of expertise. Survey respondents should be selected to provide a composite view of the larger population. In this respect, a survey can capture the views of those who that are not ordinarily informed or involved in transportation processes (including those who may not have the time to participate in visioning or other public involvement initiatives). One drawback of the survey is that it is not interactive.
- *Focus group*—The focus group is another tool to gauge public opinion, and identify citizen concerns, needs, wants, perceptions and expectations. A focus group is a small group discussion with professional leadership. Participants in a focus group are selected in two ways: random selection to assure representation of a cross-section of society or non-random selection to help elicit a particular position or point of view. A focus group can help conform or deny established goals. A focus group is relatively inexpensive compared with the costs and effort of administering a full opinion survey.
- *Collaborative task force*—A group of community leaders and private citizens could be formed as a task force that would meet periodically throughout the process of indirect effects analysis. The task force could provide direction and consultation on the methods, assumptions and analysis results and serve as the first venue for a visioning or focus group exercise.

  A collaborative task force has the following basic features:

  – A sponsoring agency that is committed to the process,
  – A task force formed of representative interests,
  – Emphasis on resolving an issue through task force consensus,
  – Detailed presentations of material and technical assistance for complete understanding of context and subject matter, and
  – Serial meetings to understand and deliberate the issues.

  A collaborative task force can require relatively significant resources. Among these are an experienced, neutral facilitator, staff technical support, presentation materials understandable to lay individuals, and, usually, specialized consultants. Several meetings are likely, each consuming several hours.

Any public involvement effort should be inclusive and comprehensive. A proactive position toward recruiting participants should be taken and every effort should be made to represent the full range of community interests in visioning, focus groups, or surveys. The goals of low-income, minority or other traditionally disadvantaged populations must be considered along with those who may be more active in the community. A list of those who may have valuable input into the process includes those with knowledge of, or interest in, local land use decisions.

Potential Visioning, Focus Group, and Task Force Members

Municipal or County Legislative Members
Mayors and County Executives
Tribal Leaders/Representatives
MPO Representatives
Regional Planning Authority Representatives
Zoning/Planning Board Members
Local Transportation/Transit Officials
Public Safety Officials
Public Works Officials
Board of Education Officials
Economic Development Officers
Utility Representatives
Community/Neighborhood Group Leaders
Environmental Organizations
Land Conservation Organizations
Religious Leaders
Business Owners and Executives
Chamber of Commerce Representatives
Realtors
Bankers
Developers
Farmers
Building Managers/Business Park Operators
Other Private Citizens

There is obviously some sensitivity involved in exploring the directions and goals of plans developed by others. For this reason, visioning is recommended as a public involvement tool in most situations for determining or confirming the area's directions and goals for the future at a broad level. Visioning can be used to develop alternative future scenarios for eventual comparison to the proposed project scenario. The citizen survey or focus group techniques can be used to support visioning when more details about directions and goals are required. Task forces can be employed in more complex project circumstances.

WORK PRODUCT OF STEP 2

The product of work for Step 2 consists of comprehensive lists (completed Figure 4-3 and 4-4 checklists, for example) detailing study area goals and trends. The sponsoring transportation agency should be responsible for preparing the lists, sharing it with those who participated in its development, and finalizing its content following review and comment by participants. The list can be used to support a technical memorandum which synthesizes the study area's relevant plans, trends, policies and shaping forces. The technical memorandum is suggested in more complex situations.

COURSE MODULE **5**

STEP 3—INVENTORY NOTABLE FEATURES

OVERVIEW

An inventory of baseline environmental conditions (or screening) is typically done as a project proposal is being developed, usually prior to the NEPA class of action determination. The typical inventory has become fairly routine, and the sources of data to undertake the typical inventory are relatively well established. The baseline environmental screening can be used as a tool to identify notable features, or specific valued, vulnerable, or unique elements of the environment. Because indirect effects analysis often involves a study area larger than that which may be necessary for analysis of direct impacts, attempts should be made to incorporate consideration of a study area for indirect effects early in the planning or project development process. An analysis of indirect effects occurring after the initial screening effort should use previous work on notable features, expanding the review to match study area boundaries or modifying it to meet the needs of indirect effects analysis as necessary. The objective of this step is to identify specific environmental issues within the indirect effects analysis study area against which the project may be assessed.

This module will

- Discuss general considerations in developing an inventory of notable features;
- Define the range of notable features relevant for inclusion in the inventory, including those addressed by federal statute;
- Review data sources and methods useful in developing the inventory; and
- Provide checklists useful in applying this step to practice.

CONSIDERATIONS

Whether from encroachment-alteration or project-influenced changes, indirect effects from transportation projects change the environment. Society has preferences for how much change is acceptable. The acceptability of the degree of change varies depending on the affected setting or population. A number of terms are found in the literature that describe settings or populations commonly afforded special attention with respect to change. The term *notable features* is used in this handbook as an overarching term that encompasses the various terms found in the literature. This term includes the following aspects of the human environment.

Sensitive Species and Habitats—U.S. EPA uses terms such as *sensitive species* and *habitats* noting that the term sensitive applies to ecologically valuable species and habitat, and those vulnerable to impact. U.S. EPA added that rarity is often a good indicator of vulnerability (EPA, 1994). U.S. EPA notes other characteristics as being indicative of vulnerability as: (a) species requiring high survival rates rather than high reproduction rates, (b) species whose intrinsic rates of increase fluctuate greatly, and (c) communities with vulnerable keystone predators or mutualists.

Valued Environmental Components—Irwin and Rodes (1990) use the term *valued environmental component* as a "characteristic or attribute of the environment that society seeks to use, protect, or enhance."

Relative Uniqueness, Recovery Time, Unusual Landscape Features—Forman and Godron (1986) use the terms *relative uniqueness* and *recovery time* as measures of a landscape element's (ecosystem's) value. Relative uniqueness is "a measure of how many comparable examples of this landscape element exist at different levels of scale, from the local area to the nation, even the globe." Recovery time is "a measure of how long it would take to replace the existing landscape element in comparable form if it were disturbed or destroyed." The authors also note the importance of *unusual landscape features,* that is, "types of landscape elements only found once or a few times across an entire landscape." Such features (e.g., a single major river in a landscape) are notable as activity centers "where flows of species, energy, or materials are concentrated."

Vulnerable Elements of the Population—The field of social impact assessment also recognizes vulnerable elements of the population (ICOGP, 1993). It has been suggested that vulnerable segments of the population of a neighborhood or community include the elderly, children, disabled persons, and members of low-income or minority groups. Such segments may be more at risk from the effects of air pollutant emissions (e.g., the elderly, children), susceptible to changes in pedestrian mobility (the elderly, children, disabled persons), or typically underrepresented in providing input to transportation decisions.

What constitutes a notable feature depends on perspective (there are likely many other perspectives or disciplines of study not discussed here that are captured by the term notable features). Therefore, the inventory should cast as wide a net as possible on perspectives. Similarly, the definition of notable features in an area depends on scale. What is notable to a region will often differ from what is notable to a community or city. The various geographic scales should be examined in keeping with the CEQ regulations which state that significance varies with context (40 CFR 1500-1508).

METHODS

There are several basic steps in assembling an inventory of notable features and a variety of data sources and basic methods to be used. To achieve optimum results in later steps of the indirect effects analysis process, every element considered here should be mapped using GIS or other cartographic techniques. Subsequent steps in this analysis framework will benefit from generation of overlay maps including notable environmental features, project design features, and subarea boundaries. Basic procedures in this part of the indirect effects assessment framework include the following steps.

Step 3A—Assemble Inventory of Ecosystem Conditions

U.S. EPA's report on ecosystem approaches to highway impact assessment (1994) suggests several ecosystem conditions to consider depending on the setting (suburban, rural, or wildland). Figure 5-1 lists those conditions and provides a framework for documentation by the analyst. Data sources for ecosystem conditions include the following:

- Nature Conservancy data, available through state Natural Heritage Programs (NHPs) or Conservation Data Centers (CDCs), contain information on regional biological and ecological features including rare species communities.
- U.S. Geological Survey (USGS) Biological Resources Division, consolidates information on biological and ecological features from several Department of Interior bureaus.
- U.S. EPA Environmental Monitoring and Assessment Program (EMAP) has developed detailed methodologies and indicators for assessment of baseline ecological conditions. This program is currently in the implementation phase, but information on select resources and regions is currently available.
- State land management agencies.
- State fish, wildlife, and conservation agencies.
- State agricultural and forestry agencies.
- Tribal natural resource offices.

Step 3B—Assemble Inventory of Socioeconomic Conditions

Identification of features in the human social environment begins with an inventory of basic socioeconomic conditions. Figure 5-2 details basic economic, demographic, social, and physical conditions linked to notable features and provides a framework for their documentation. The conditions outlined were drawn from the community impact assessment literature (Pivo, 1992).

Data required for this step are similar to that required for Step 2 of the indirect effects assessment framework (see Module 4). Data gathering for the two steps should be integrated whenever possible. Potentially useful sources of socioeconomic information are discussed below.

- *Published statistics*—Existing measures and future projections of demographic and economic factors in an area can be obtained from the following sources:
  - The U.S. Census provides data on population and household demographics, income, education, housing type, journey to work, and length of residence in an area
  - The number and type of jobs in a study area for current and historical periods may be obtained through data on Covered Employment (ES-202) maintained by state departments of labor and industry. The number of jobs divided by the number of households in a study area determines the jobs/housing balance, a measure of self-containment.
  - In metropolitan areas, MPOs maintain data current employment and population conditions as well as projections for future time periods which account for pending and anticipated development projects.
- *Other published material*—Locally published sources may be relevant to the study. These include the following:
  - Local comprehensive plans (see Module 4) often include discussions of socioeconomic conditions such as demographics and income; social conditions such as crime rate and social organizations; and physical features, such as densities, form, mix of land uses, and historic structures.
  - Historical studies of communities conducted by historical societies or local universities may provide information on trends in conditions.
  - Newspaper articles may contain information on local conditions, features, and public opinion.
- *Interviews*—Because of the age or incompleteness of statistics and local plans it may be necessary to conduct interviews with local government and planning officials to ascertain or confirm information on social and physical conditions.
- *Public involvement*—Citizen surveys or focus groups can be conducted to inquire about what residents like most about the area, where they would take visitors to give them a feel for the area (uniqueness).

Project Name: ____________ Location: ____________ Analyst: ____________ Date: ________

Setting	Describe/Characterize (Map Locations)
___ Suburban Landscapes Remnant Communities Greenways Remnant Populations Wetlands and Riparian Zones Drainage Patterns Natural Vegetation Diversity	
___ Rural Watersheds Local Ecosystem Integrity Riparian Corridors Endemics and Migratory Species Riparian and Forest Corridors Hydrology Landscape Pattern Diversity Dispersal Routes	
___ Wildland Regional Ecosystems Remote Habitat Contiguous Habitat Habitat Interior Species Unique Environments Structural Components of Interior Habitat Subpopulation Movements	

Reviewed by: Name Affiliation Date

Figure 5-1. Ecosystem conditions inventory.

- *Field work*—Field investigations may be necessary to confirm secondary source information or to investigate items not identified through readily available information. Following confirmation, the location and extent of inventoried items should be mapped and/or tabulated.

Step 3C—Assemble Inventory of Notable Features

Notable features gleaned from investigations into ecological and socioeconomic conditions may be documented using the framework given in Figures 5-3 and 5-4. Figure 5-3 outlines the major types of notable features. Figure 5-4 was prepared to note that through enactment of laws, society as a whole has in effect placed a value on certain resources or determined that certain resources require special consideration before actions like transportation projects are undertaken. The table lists pertinent federal laws; state and local transportation agencies should expand the list to include pertinent state and local laws.

It is possible that a project study area could contain a number of possible notable features, and differing views of what is notable or why it is notable. For these reasons, it is in a transportation agency's interest to have as many interested parties as necessary involved in determining what are notable features for a particular study area, especially when the study area is large in area or contains many complex features.

- *Collaborative task force*—The collaborative task force public involvement technique described in Module 4 is ideally suited to consultation on notable features. Following data collection, the transportation agency should assemble a preliminary list of notable features for potential use as impact measures in the indirect effects analysis. The same list could be used for direct and cumulative impact analysis, as well. This list would form the basis of discussion at a collaborative task force meeting(s). The final list of selected assessment notable features should reflect the task force consensus.

Project Name: ________________ Location: __________ Analyst: __________ Date: ________

	Describe/Characterize
Economic	
Residents' occupational mix	________
Jobs in community (mix)	________
Jobs/housing balance (self-containment)	________
Income distribution mix	________
Journey to work (length and mode)	________
Job growth rate	________
Business ownership and services characteristics	________
Demographic	
Population growth rate	________
Population age mix	________
Household types	________
Retired population percent	________
Social	
Community cohesion	________
Crime rates	________
Clubs, sports and organizations participation	________
Education levels mix	________
Sense of control over change	________
Balance of old timers and newcomers	________
Physical	
Housing stock mix and values	________
Open space percent	________
Town area and form	________
Separation from other activity centers	________
Residential density	________
Mix of land uses	________
Town edge activity	________
Historic structures and places	________
Circulation and traffic characteristics	________
Neighborhood design characteristics	________
Infrastructure character	________
Commercial building scale	________
Town entrance setting	________
Scenic character	________
Trees and vegetation presence	________
Noise levels and timing	________
Lighting influence	________

	Name	Affiliation	Date
Reviewed by:			

Figure 5-2. Socioeconomic conditions inventory.

Project Name: ________________ Location: ___________ Analyst: __________ Date: ________

	Specify
Ecosystem Features	
___ Regional habitats of concern/critical areas	________________________
___ Rare, threatened or endangered species and associated habitat	________________________
___ Species requiring high survival rates	________________________
___ Species whose intrinsic rates of increase fluctuate greatly	________________________
___ Communities with vulnerable keystone predators or materialists	________________________
___ Other ________________	________________________
Socioeconomic Features	
___ Substandard amounts of open space and recreation	________________________
___ Non-compliance with state and federal environmental laws	________________________
___ High concentration of uncontrolled solid and hazardous waste sites	________________________
___ Inadequate affordable housing	________________________
___ Inadequate access to amenities	________________________
___ Economically distressed areas	________________________
___ Lack of institutional land use controls	________________________
___ High proportion of population consisting of:	________________________
___ Minorities	________________________
___ Low-income residents	________________________
___ Elderly	________________________
___ Young	________________________
___ Disabled	________________________
___ Low proportion of long-term residents	________________________
___ Locations of poor traffic flow	________________________
___ Other ________________	________________________

Reviewed by: Name Affiliation Date

Figure 5-3. Notable features checklist.

Project Name: ________________ Location: ____________ Analyst: ___________ Date: ________

Resource Type or Area	Statute/Order	Source of Information and Map Locations
___ Section 4(f) Resources ___ Public Parks and Recreational Lands ___ Wildlife and Waterfowl Refuges ___ Historic Sites ___ Historic Districts ___ Archaeological Remains ___ Historic Structure	Department of Transportation Act	Local Parks or Recreation Officials, State Historic Preservation Office or local historic preservation organizations
___ Coastal Zone	Coastal Zone Management Act	State Coastal Zone Management Office
___ Waters of the United States	Clean Water Act; E.O. 11990	State Fish and Game Commission; U.S. Fish and Wildlife Service
___ Sole Source Aquifer	Safe Drinking Water Act	State Natural Resources Agency; U.S. Environmental Protection Agency
___ Areas of Known Contamination	Comprehensive Env. Response Compensation Liability Act	State environmental protection agency; U.S. Environmental Protection Agency
___ Floodplains	E.O. 11988	Federal Emergency Management Agency
___ Range or Habitat of Threatened or Endangered Species	Endangered Species Act	State Fish and Game Commission; U.S. Fish and Wildlife Service
___ Wild, Scenic or Recreational River	Wild and Scenic Rivers Act	U.S. National Parks Service
___ Prime or Unique Farmland	Farmland Protection Act	U.S. Soil Conservation Service
___ Sensitive Receptor	Clean Air Act; Noise Control Act	State environmental protection agency
___ Nonattainment or Maintenance Areas	Clean Air Act	State and local air and transportation agencies; metropolitan planning organizations; state implementation plans; conformity determinations of transportation plans, programs and projects
___ Residential or Commercial Establishments	Uniform Relocation Act; E.O. 12898	Local governments

Reviewed by: Name Affiliation Date

Figure 5-4. Notable features addressed by federal statutes.

APPLICATION TO PRACTICE

Transportation Systems Planning Context

An inventory of notable features is important in the planning of transportation systems because it can help establish need (improving systems in lower-income areas with poor access) and can help planning agencies minimize potential conflict between the proposed systems and notable features. An inventory on the scale necessary for systems planning will necessarily be less detailed than that suitable for project evaluation. Such an inventory will consider larger or more significant features notable on a regional scale. Development of overlay maps or a GIS database indicating the location and extent of these major socioeconomic and ecological features will facilitate anticipation of direct, indirect, and cumulative effects early in the process.

Project Evaluation Context

The methods and data sources discussed above are suitable for compiling an inventory of notable features on a broad regional scale or a very local scale. At the project evaluation stage generating an inventory of features notable in each community or subregion of the study area is appropriate. Scoping (see Module 3) will provide an indication of the level of effort required or areas that will require particular attention.

WORK PRODUCT OF STEP 3

The product from the work conducted during this step consists of documents completed in accordance with Figures 5-1 through 5-4, with an accompanying map or GIS database illustrating the location and extent of each notable feature, where appropriate. The list should be prepared by the sponsoring transportation agency with a collaborative task force (where necessary) and shared with those who participated in its development.

REFERENCES

Forman, R., and Godron, M. *Landscape Ecology*. John Wiley & Sons, New York, NY (1986).

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COURSE MODULE **6**

STEP 4—IDENTIFY IMPACT-CAUSING ACTIVITIES OF THE PROPOSED ACTION AND ALTERNATIVES

OVERVIEW

Steps 2 and 3 of the indirect effects assessment framework have focused on the identification of trends, goals, and notable features. The next steps in the framework involve identification and assessment of impacts that may come into conflict with these goals and features. Gaining a thorough understanding of project design features and the range of impacts they may cause is the first step toward the identification of indirect effects. Project impact-causing activities are relevant to two of the three types of indirect effects:

Encroachment-Alteration Effects—Effects that alter the behavior and functioning of the physical environment are related to project design features but are indirect in nature because they can be separated from the project in time or distance.

Access-Alteration Effects (Project-Influenced Effect)— Changes in traffic patterns and the alteration of accessibility attributable to the design of the project can influence the location of residential and commercial growth in the study area.

Induced growth-related effects, the third type of indirect effect, are attributable to induced growth itself not project design features.

The key source of information regarding project features is the project description. Typically, the transportation project description consists of basic information that describes the facility to result from the proposed action or alternative (e.g., estimated year of completion, type and function of facility, project length, termini, and access points, and number of lanes). This is especially true in early project stages before detailed information becomes available from preliminary design studies. It is clear from this study's research findings that a more detailed project description than is typical is needed to make indirect effects more apparent earlier in the project planning and development process.

The objective of this step in the framework is to go beyond the typical project description to flesh out those impact-causing activities that a project will entail. This is consistent with the overall framework objective of promoting consideration of indirect effects earlier in the transportation project development process. This is an exercise that occurs formally or informally during the environmental impact assessment of a project. Research done in support of this indicates that this exercise is typically done by the analysts who prepare the environmental consequences section of the EIS (i.e., after preparation of the affected environment section of the EIS or later in the process rather than sooner). However, with a complete description as possible of the proposed action and alternatives early on, it is possible to begin the process of identifying cause-effect relationships between activities and the context of the study area as defined by goals and notable features.

This module will

- Discuss considerations involved in gathering data on impact-causing activities when project specifications are not fully developed,
- Outline the major types of impact-causing activities, and
- Provide a framework for documentation of impact-causing activities.

CONSIDERATIONS

A transportation project may involve a number of impact-causing activities. Few details may be known about these activities at the early stages of project planning or development beyond the basic project design concept and scope. Therefore, this step may require some leaps of faith by those developing the description, as well as an understanding that the information provided is for purposes of conceptualizing, not quantifying, effects. In other words, what is important at this point is identification of the types of activities that the project will entail. This step can be accomplished with a level of detail commensurate with 400-scale mapping.

An understanding of the transportation agency's past practices in similar situations (e.g., bridging of streams versus placing a stream in a culvert) as well as knowledge of relevant sections of the agency's design manual and standard specifications is needed. Some experience is necessary to make judgements on these items.

The project description should also be viewed as a piece that will evolve, and it should be updated as details about the project become known with more certainty. In particular, the linking of impacts and goals/notable features in Step 5 (see Module 7) should prompt development of more details on activities that have potential for significant impact, where such details are lacking.

METHODS

Figure 6-1 presents a checklist developed from the literature (Leopold, 1971) that can be used to help flesh out typical

Project Name: __________________ Location: ____________ Analyst: ___________ Date: _________

	Yes	No	If Yes, Describe Generally (Breadth, Duration, Location and Type)
Modification of Regime			
Exotic Flora Introduction			
Modification of Habitat			
Alteration of Ground Cover			
Alteration of Groundwater Hydrology			
Alteration of Drainage			
River Control and Flow Modification			
Channelization			
Noise and Vibration			
Land Transformation and Construction			
New or Expanded Transportation Facility			
Service or Support Sites and Buildings			
New or Expanded Service or Frontage Roads			
Ancillary Transmission Lines, Pipelines and Corridors			
Barriers, Including Fencing			
Channel Dredging and Straightening			
Channel Revetments			
Canals			
Bulkheads or Seawalls			
Cut and Fill			
Resource Extraction			
Surface Excavation			
Subsurface Excavation			
Dredging			
Processing			
Product Storage			
Land Alteration			
Erosion Control and Terracing			
Mine Sealing and Waste Control			
Landscaping			
Wetland or Open Water Fill and Drainage			
Harbor Dredging			
Resource Renewal			
Reforestation			
Groundwater Recharge			
Waste Recycling			
Site Remediation			
Changes in Traffic (including adjoining facilities)			
Railroad			
Transit (Bus)			
Transit (Fixed Guideway)			
Automobile			
Trucking			
Aircraft			
River and Canal Traffic			
Pleasure Boating			
Communication			
Operational or Service Charge			
Waste Emplacement and Treatment			
Landfill			
Emplacement of Spoil and Overburden			
Underground Storage			
Sanitary Waste Discharge			
Septic Tanks			
Stack and Exhaust Emission			
Chemical Treatment			
Fertilization			
Chemical Deicing			
Chemical Soil Stabilization			
Weed Control			
Pest Control			
Access Alteration			
New or Expanded Access to Activity Center			
New or Expanded Access to Undeveloped Land			
Alter Travel Circulation Patterns			
Alter Travel Times between Major Trip Productions and Attractions			
Alter Travel Costs between Major Trip Productions and Attractions			
Others			

	Name	Affiliation	Date
Reviewed by:			

Figure 6-1. Project impact-causing activities checklist.

impact-causing activities of transportation projects. For a given project, pertinent impact-causing actions can be viewed as potential catalysts for indirect effects.

Available project information should be consulted to complete the checklist. The question for the analyst is: does the tabulation provide sufficient information about the breadth, duration, location, and type of activity such that the general types of impacts to be expected from the project can be inferred. If not, assumptions will need to be made based on standard practice, as discussed above.

If there is a substantial difference between an assumption and the detail developed at a later time regarding a particular activity (e.g., use of fill material rather than structure) then an assessment needs to be made of whether or not the difference causes a substantial change in either the identification of potentially significant indirect effects (Step 5; Module 7); the analysis of the effects (Step 6; Module 8); or the conclusions regarding the acceptability of the effects (Step 8; Module 10). This assessment can be done using the sensitivity analysis or risk analysis task described in Step 7 (Module 9).

The general types of project impact-causing activities include the following:

- *Modification of regime*—alteration of habitat, flora, hyrdrology, and other features;
- *Land transformation and construction*—construction method, ancillary elements;
- *Resource extraction*—excavation and dredging;
- *Processing*—storage of supplies;
- *Land alteration*—landscaping, erosion control;
- *Resource renewal activities*—remediation, reforestation;
- *Changes in traffic*—traffic patterns on project and adjoining facilities;
- *Waste emplacement*—landfill, waste discharge;
- *Chemical treatment*—fertilization, deicing;
- *Access alteration*—changes in access, circulation patterns, travel times to major attractors.

APPLICATION TO PRACTICE

Transportation Systems Planning Context

Using Figure 6-1 as a guide, the general attributes of each plan component or mode should be described in as much detail as possible. These descriptions would be based on assumptions derived from standard practice, previous experience or professional judgment. The location of potential impact-causing activities should also be described in a general manner.

Project Evaluation Context

Project features that may result in impacts should be described with as much specificity as possible with assumptions substituted for detailed information as necessary. A list should be made of assumptions used to fill in gaps where details about activities are lacking. This list should be consulted and updated as details are developed but no less frequently than the inception of each subsequent step of the indirect effects assessment process.

WORK PRODUCT OF STEP 4

The product of this step consists of a comprehensive list (completed Figure 6-1 checklist) of the impact-causing actions of the proposed plan or project and alternatives, in as much detail as possible. The list would usually be prepared by the sponsoring transportation agency.

REFERENCE

Leopold, L. *A Procedure for Evaluating Environmental Impact. Geological Survey Circular 645.* Department of the Interior, Washington D.C. (1971).

COURSE MODULE **7**

STEP 5—IDENTIFY POTENTIALLY SIGNIFICANT INDIRECT EFFECTS FOR ANALYSIS

OVERVIEW

Section 101(a) of NEPA, "Declaration of National Environmental Policy," reads as follows:

> The Congress recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high density urbanization, industrial expansion, resource exploitation and new and expanding technological advances . . . declares that it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, . . . to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic and other requirements of present and future generations of Americans.

This language has two elements pertinent to indirect effects analysis: (1) the recognition of the impact of human activity on the *interrelations* of all components of the natural environment and (2) the implication that the impact should be balanced against other considerations. This step deals with the first of these elements; the second element is the subject of Step 8, where the use analysis results in planning and decision making is discussed. The objective of this step is to compare the list of project impact-causing actions with the lists of goals and notable features to explore potential cause-effect relationships and establish which effects are potentially significant and merit subsequent detailed analysis (or, conversely, which effects are not potentially significant and require no further assessment).

This module will

- Describe the range of indirect effects related to encroachment alteration, including ecological and socioeconomic effects.
- Describe three types of induced growth effects: (1) effects from projects planned to serve specific land development, (2) effects from projects likely to stimulate complementary development, and (3) effects from projects likely to influence intraregional land development.
- Summarize qualitative and quantitative methods that can be used to identify indirect effects.
- Present considerations and a set of questions in decision tree format for assessing the significance of identified effects.

CONSIDERATIONS

The discussion of general issues is organized by the three basic types of indirect effects: encroachment-alteration effects, induced growth effects, and effects related to induced growth. Potential effects in each of these categories should be considered for their relevance to the project and significance in the study area. A discussion of the methods and criteria available for determining relevance and significance of effects follows.

Encroachment-Alteration Effects

Alteration of the behavior and functioning of the affected environment caused by project encroachment can be characterized into two broad categories: ecological effects and socioeconomic effects. These effects can be linked to project impact-causing activities identified in the previous step. The two main effect types are discussed below.

Ecological Effects

The ecosystem approach embodied in CEQ's biodiversity document (1993) recognizes the "fundamental interconnections within and among various levels of ecological organization." Ecological organization is a hierarchically arranged continuum as illustrated in Figure 7-1. Reduction of diversity at any level will have effects at the other levels. Therefore, an understanding of the interconnections can help reveal the chain of events delayed in time or space from the original transportation project action or disturbance on or within a particular level of ecological organization.

The interconnections in ecosystems are numerous and complex. Many ecological communities are constantly changing. However, there is a certain range of possibilities that help define a given community. In the absence of a major disruption, species composition and relative abundance in a community can be expected to vary within definable boundaries, perhaps cyclically or perhaps randomly. Disruption of such systems (e.g., the introduction of contaminants) creates new boundaries, changing the range of possibilities in ways that are not always predictable.

Transportation corridors have unique impact on ecosystems associated with their linear form. These corridors may func-

- **Regional ecosystem diversity:** The pattern of local ecosystems across the landscape, sometimes referred to as "landscape diversity," or "large ecosystem diversity."

- **Local ecosystem diversity:** The diversity of all living and non-living components within a given area and their interrelationships. Ecosystems are the critical biological/ecological operating units in nature. A related term is "community diversity," which refers to the variety of unique assemblages of plants and animals (communities). Individual species and plant communities exist as elements of local ecosystems, linked by processes such as succession and predation.

- **Species diversity:** The variety of individual species, including animals, plants, fungi and microorganisms.

- **Genetic diversity:** Variation within species. Genetic diversity enables species to survive in a variety of different environments, and allows them to evolve in response to changing environmental conditions.

The **hierarchical nature** of these components is an important concept. Regional ecosystem patterns form the basic matrix for, and thus have important influences on, local ecosystems. Local ecosystems, in turn, form the matrix for species and genetic diversity, which can in turn affect ecosystem and regional patterns.

Relationships and interactions are critical components as well. Plants, animals, communities and other elements exist in complex webs, which determine their ecological significance.

(CEQ 1993)

Figure 7-1. Components of biological diversity.

tion as specialized habitats, conduits of movement, barriers or filters to movement, or sources of effects on surrounding habitats. Improvements within corridors can have consequences to habitats removed in time and distance from the project. Together with other human actions the cumulative effects can be significant.

The following indirect and cumulative effects of transportation project actions can have important consequences for ecosystems (see Figure 7-2):

- Habitat fragmentation from physical alteration of the environment;
- Lethal, sublethal, and reproduction effects from pollution;
- Degradation of habitat from pollution;
- Disruption of ecosystem functioning from direct mortality impacts; and
- Disruption of natural processes (i.e., hydrology, species competition, predator-prey relations, etc.) from altered energy flows.

The ability of an ecosystem to respond to a disturbance or perturbation from a transportation project is a function of its *resistance* (the ability of the ecosystem to withstand or resist variation imposed by disturbance or perturbation) and *recovery* (the ability of an ecosystem to respond after being changed). Note that different elements of an ecosystem will have different rates of resistance and recovery which also interact with each other.

Socioeconomic Effects

Encroachment by transportation projects can directly affect the physical nature of a neighborhood in two major ways: (1) alteration of traffic patterns and access and (2) relocation of homes and businesses, or relocation or alteration public facilities.

These direct effects can result in indirect effects that can be magnified by the cumulative impacts of other actions. These effects include alterations to the following:

- Neighborhood cohesion,
- Neighborhood stability,
- Travel patterns of commuters and shoppers,
- Recreation patterns at public facilities,
- Pedestrian dependency and mobility,
- Perceived quality of the natural environment,
- Personal safety and privacy, and
- Aesthetic and cultural values.

These variables should be used to explore effects of changes in the physical environment from transportation projects. For example, a highway project can physically alter the local street network and/or increase traffic volumes on local streets, both of which could effect pedestrian mobility and consequently, interactions and neighborhood satisfaction.

The categorization of effects on the environment presented in Figure 7-3 can be a useful tool for identifying socioeconomic indirect effects. Of particular note is the opportunity-

Direct Effect	Indirect Effect	Some Manifestations	Possible Consequences (from individual effects or combination of effects)
• Physical Alteration—Habitat Destruction	• Habitat Fragmentation	• Creation of Smaller Patches • Creation of Barriers • Creation of More Edges • Draining or Ponding	• Local extinction of wide-ranging species • Loss of interior or area-sensitive species • Direct mortality impacts • Erosion of genetic diversity and amplification of inbreeding (particularly for isolated sedentary species) • Increased probability of local extinction from small population sizes and reduced likelihood of re-establishment (because immigration is inhibited by barriers) • Increased abundance of weedy species • Generally, reduced biological diversity
• Introduction of Pollutants—Toxicity and Behavioral Effects	• Degradation of Habitat	• Changes in Reproductive Behavior and Rates • Changes in Food Sources	• Changes in Community Structure—relative abundance of various species • Changes in Ecosystem Structure and Function
• Alteration of Natural Processes—e.g., Hydrology, Species Interactions (e.g., competitor and predator—prey), migration	• Altered Energy Flows	• Changes in Population Sizes from effects on births, deaths, immigration and emigration • Changes in Vegetative Structure	• Change in Ecosystem Ability to Support Life

Figure 7-2. Some possible effects on ecosystems from transportation projects.

System Affected	Temporal Phase		
	Opportunity-Threats	Development/Event	Adaptation/Post-Development
Physical	Anticipatory construction or lack of maintenance, decay of existing structures and facilities.	Potential massive alteration of the physical environment, construction of new and upgrading of existing facilities.	Creation of development-specific facilities, deterioration of alternative productive facilities, destruction of environment.
Cultural	Initial contact, new ideas, potential for loss of cultural continuity.	Suspension of activities that assure cultural continuity (e.g., subsistence harvest).	Gradual erosion of culture: loss of unique knowledge, skills, and/or perspectives.
Social	Organizational changes investment of time, money, or energy for support or resistance; differential construction of risk.	Population increase, influx of outsiders: decline in density of acquaintanceship: social change.	Gradual loss of social human capital (e.g., organizational networks and skills, replacements having limited optional application).
Political/Legal	Litigation to force or block proposed development, heightened political claims-making.	Intrusion of development activity into community politics, litigation and conflict over activity impacts.	Zoning and regulatory changes in search of new development, new laws/ruling in response to impacts.
Economic	Decline or increase in property values, speculation, investment.	Traditional boom/bust effects, inflation, entrance of outsiders into local labor market.	Loss of economic flexibility, specialization of business.
Psychological	Anxiety, stress, anger: gains or losses in perceived efficacy.	Stress associated with rapid growth, psycho-social pathology, loss of efficacy.	Acquisition of coping strategies that are potentially maladaptive under future scenarios.

Source: Gramling and Freudenberg, p. 218.

Figure 7-3. Conceptual approach to effect identification.

threat category of effects, that is, those that can occur while a project is planned but before construction. Examples include effects on real estate investment and maintenance of property. Such effects may indicate the long-term indirect effects that can be expected once a project is implemented.

It is important to note that the ecological and socioeconomic encroachment-alteration effects described above can also arise from induced growth which is itself an indirect effect. Induced growth effects are described below.

Induced Growth Effects

Transportation improvements often reduce the time-cost of travel, enhancing the attractiveness of surrounding land to developers and consumers. Development on vacant land, or conversion of the built environment to more intensive uses, is often a consequence of highway and transit projects. Growth in population and employment attributable to a direct project effect (change in accessibility) is an indirect effect that, in turn, produces its own effects on the environment.

Important characteristics of induced growth are described below and illustrated in Figures 7-4 through 7-6:

- The land use impacts of highway investment vary depending on existing land use conditions in the project area (see Figure 7-4).
- Transportation investments can prompt changes in economic, social, and demographic conditions which can alter location decisions and land use (see Figure 7-5).
- A transportation investment and the increased accessibility that it brings is just one factor in the development decision-making process (see Figure 7-6). Other factors include the following:
  - Location attractiveness (physical features; suitability for development; land price and development costs; adjacency to markets, customers, and demand generators);

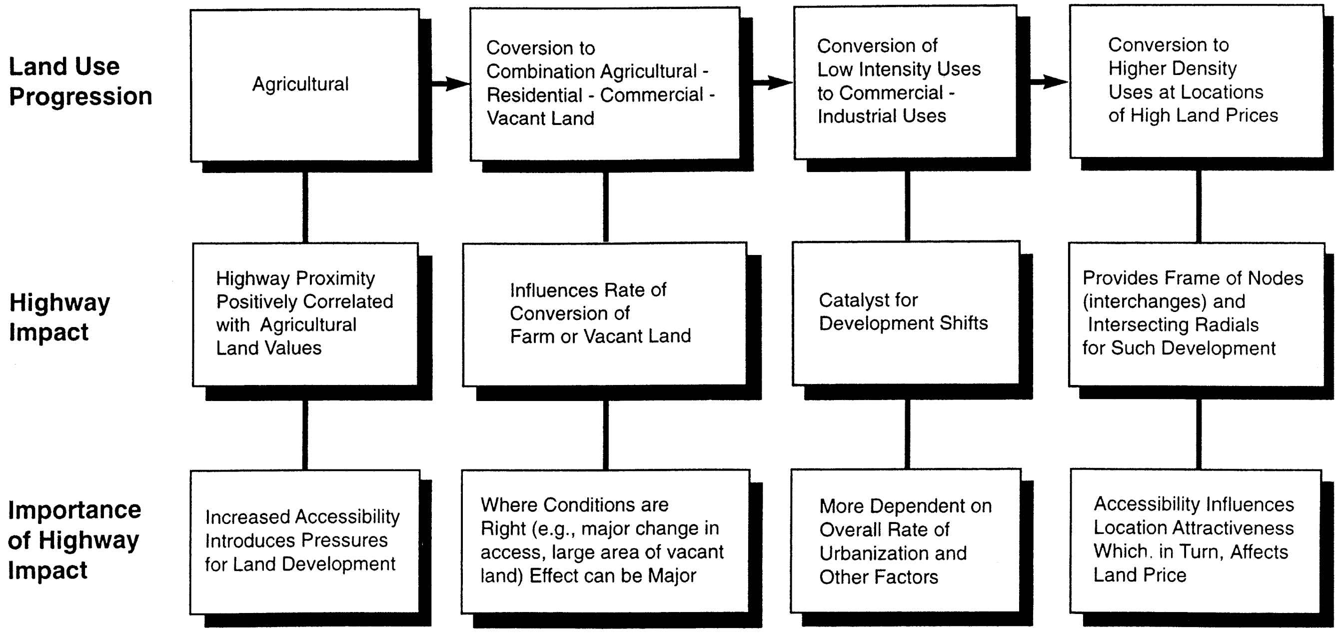


Figure 7-4. Highway investment impact on typical progress of urbanization.

- Consumer preferences (for local features, existing/anticipated development);
- The existence/availability of other infrastructure (water, sewer, communications);
- Local political and economic conditions (tax rates, incentives, regulatory environment, availability of labor and capital); and
- The rate and path of urbanization in the region.

Induced growth effects fall into three general categories: (1) effects of projects planned to serve specific land development, (2) effects of projects likely to stimulate complementary development, and (3) effects of projects likely to influence interregional locational decisions. These induced growth types are discussed in detail below.

Projects Planned to Serve Specific Land Development

Transportation projects designed specifically to serve existing or planned large land development projects or groups of projects require a thorough analysis of induced growth and related effects. This is because: (a) land development is not just probable but highly likely, (b) the magnitude and timing of the development are known or generally predictable, and (c) details of development projects are known and can be analyzed for environmental effects.

Because the land development projects are known, analysis of this type of growth is of importance to cumulative effects analysis as well as indirect effects analysis. With details about development in hand, analysis will focus on impacts related to the magnitude and timing of development than its probability of occurrence.

Projects Likely to Stimulate Complementary Land Development

Complementary land development, such as highway-oriented businesses (gas stations, rest stops, motels), is more likely near interchanges in rural areas where property values were originally low. Interchanges in suburban or urban areas where property values were higher before project planning and implementation are more likely to support a greater proportion of higher density uses, as well as a greater mix of uses. Factors influencing the likelihood and rate of development near rural interchanges include the following:

- Distance to major urban area or regional center (proximity corresponds to higher probability of development);
- Traffic volume on the intersecting road (higher volumes correspond to higher probability of development);
- Presence of frontage road (greater potential for intensive development); and
- Availability of water and sewer and other infrastructure (greater potential for development).

If these factors are present, induced growth effects of this type warrant analysis.

Common patterns of development include the following characteristics:

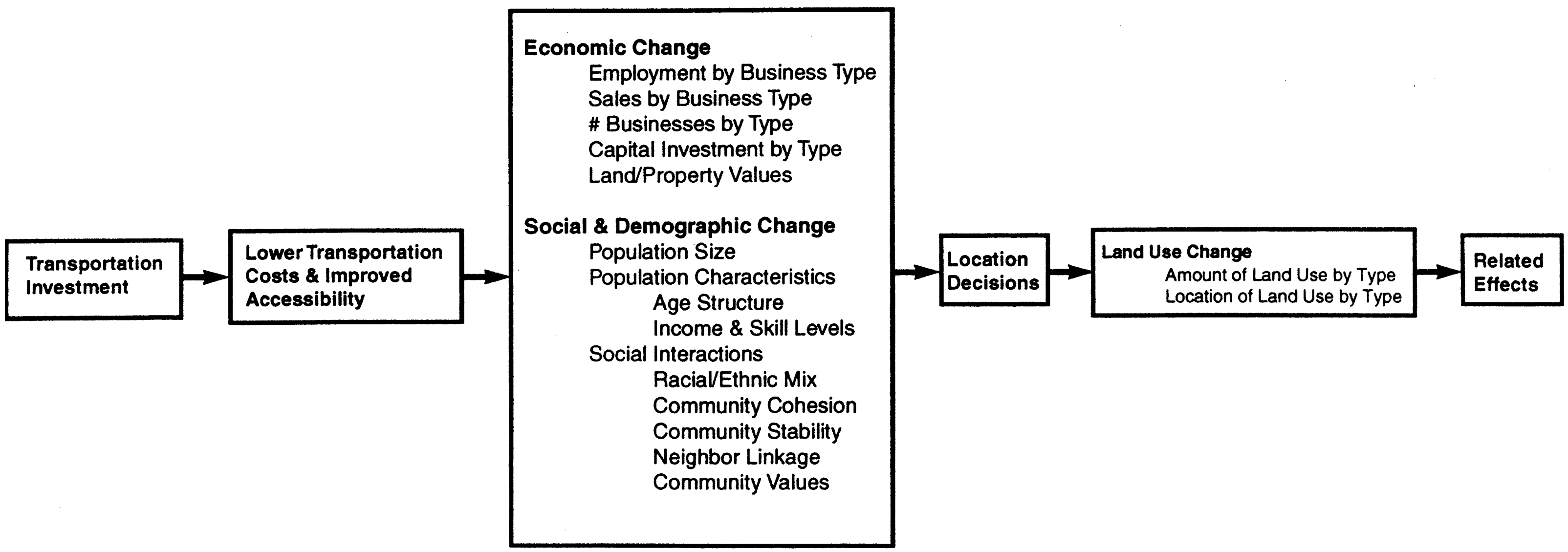


Figure 7-5. Transportation access-land use change linkage.

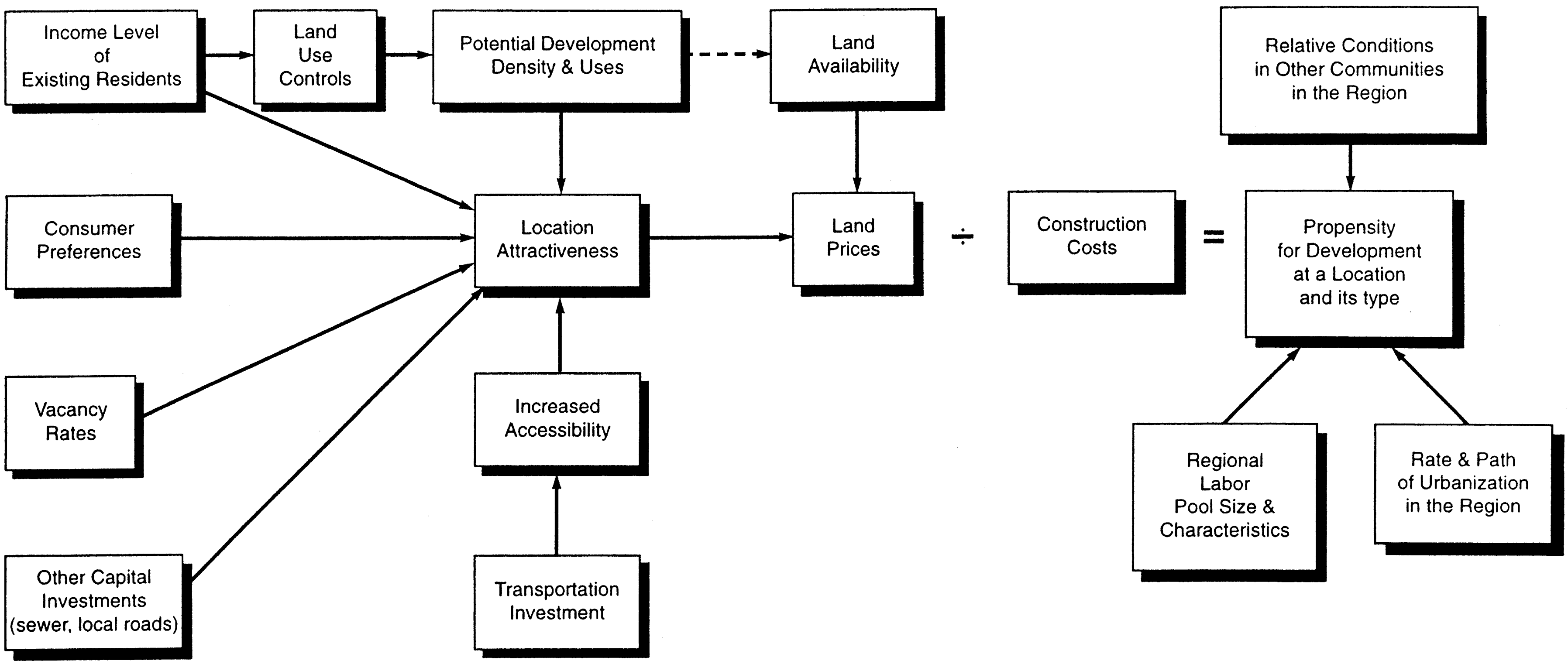


Figure 7-6. Simplified model of various factors influencing development location decisions.

- Interchange quadrants on the right-hand side of motorists approaching the interchange from the main road have higher visibility and are often developed first.
- Transit projects with stops in suburban or urban areas may produce higher density commercial and residential uses and complementary retail and service development such as coffee shops, dry cleaners, and newsstands.

Projects Likely to Influence Intraregional Location Decisions (Development Shifts)

Apart from the complementary development described above, on a regional basis, the impact of highway and transit projects is generally minimal. The localized effect of such projects on land use can be substantial, however. If the conditions for development are generally favorable in a region, that is, the region is undergoing urbanization, highway and transit projects can become one of the major factors that influence where development will occur, and project-influenced effects warrant evaluation.

Where transportation projects do influence land development, the general tendency is toward relatively high-density commercial or multifamily residential development near facility nodes in urban and suburban areas and single-family residential development in the urban fringe.

Development effects are most often found up to 1 mi around a freeway interchange, up to 2 to 5 mi along major feeder roadways to the interchange, and up to one-half mile around a transit station.

General circumstances influencing the likelihood of induced development shifts include the following:

- *Extent and maturity of existing transportation infrastructure*—The influence of highway projects diminishes with successive improvements because each new improvement brings a successively smaller increase in accessibility. Improved roads in a developing region attract more land use development, population growth, and traffic, which soon leads to congestion, reduced accessibility, and air quality impacts.
- *Land availability and price*—Development can not take place without the availability of land of a quality and price suitable for development. Property values are de-facto indicators of the potential for land use change because investment decisions revolve around market prices. Land prices are likely to reflect a parcel's suitability for development (favorable topography), the availability of other suitable parcels in the area, the attractiveness of the location and many of the other factors listed below. An abundance of suitable, low-priced land may be indicative of potential development if other factors are present. A scarcity of land or high price does not necessarily indicate a lower probability of development, however. If other factors described here are favorable, high-density development may occur where land is scarce or high priced.
- *State of the regional economy*—Even if changes in accessibility are great, development is not likely to occur if the regional economy will not support new jobs and households, if credit or financing is not readily available, or if firms conclude that the availability of labor, suppliers, or local markets for goods, are not sufficient.
- *Area vacancy rates*—High local vacancy rates in housing or commercial space of good quality may be absorbed before any shift in development to the project area is seen.
- *Location attractiveness*—The quality of existing development, local politics, growth history, are all factors considered in addition to transportation availability and cost.
- *Local political/regulatory conditions*—Low business, property, and sales tax rates; the availability of incentives for development such as tax abatements; and a regulatory environment that is favorable to business are factors favorable to development. The speed ease, or predictability of the development review process can also impact development costs and is a factor to be considered.
- *Land use controls*—Development is shaped by zoning ordinances and other land use controls that influence the amount of land available for various uses, the densities permitted, and the costs of development. Pressures for development can prompt communities to alter land use controls, however, and an evaluation should be made which considers the likelihood that changes in land use controls will occur. Such an evaluation can consider the historical record of zoning enforcement and granting of variances, whether the controls are rooted in long range comprehensive plans, and the existing amount of undeveloped land for each use.

If these conditions are favorable for development, a detailed analysis of induced growth and its potential for impact on important area goals or notable features is warranted.

Review of recent indirect effects case law suggests that analysis of induced growth effects is required whenever economic development is cited in the statement of purpose and need for the project.

Effects Related to Induced Growth

Project-influenced land development and growth can affect the environment in many possible ways. A general tabulation of possible land development effects in terms of economics, the natural environment, aesthetic and cultural values, and public and private services is presented in Figure 7-7. A tabulation of possible socioeconomic effects of land development is presented in Figure 7-8. Obviously, the degree of certainty, specificity, and need to know about the induced effects will determine the extent that the corresponding related effects should be examined.

One particular effect related to induced growth, the effect of transportation investments on air quality vis-a-vis land use

Impacted Sector	Variable	Indicator
Economic	Public Fiscal Balance	1) Net change in government fiscal flow.
	Employment	2) Number of new long-term and short-term jobs provided. 3) Change in numbers and percent employed, unemployed, and underemployed.
	Wealth	4) Change in land values.
Natural Environment	Air Pollution	5) Change in level of air pollutants and change in number of people at risk or bothered by pollution.
	Water Pollution	6) Change in the level of water pollutants, intolerable change in types of use, and number of persons affected, for each body of water.
	Noise Pollution	7) Change in noise and vibration levels, and the number of people bothered by excessive noise and vibration.
	Greenery and Open Space	8) Amount and percent change in greenery and open space.
	Wildlife and Vegetation	9) Number and types of rare or endangered species that will be threatened. 10) Change in the abundance and diversity of wildlife and vegetation in the development and community.
	Scarce Resource Consumption	11) Change in the frequency, duration, and magnitude of shortages of critically scarce resources, and the number of persons affected.
	Natural Disasters	12) Change in number of people and value of property endangered by flooding, earthquakes, landslides, mudslides, and other natural disasters.
Aesthetic and Cultural Values	Views	13) Number of people whose views or sightlines are blocked, degraded, or improved.
	Attractiveness	14) Visual attractiveness of the development as rated by citizens and "experts." 15) Percent of citizens who think the development improves or lessens overall neighborhood attractiveness, pleasantness, and uniqueness.
	Landmarks	16) Rarity and perceived importance of cultural, historic, or scientific landmarks to be lost or made inaccessible.
Public and Private Services	Drinking Water	17) Change in the rate of water shortage incidents. 18) Change in indexes of drinking water quality and safety.
	Hospitable Care	19) Change in number of citizens who are beyond x minutes travel time from a hospital emergency room (using such time as the community considers reasonable). 20) Change in average number of days of waiting time for hospital admittance for elective surgery.
	Crime Control	21) Change in rate of crimes in existing community of new development (or expert rating of change in hazard presented). 22) Change in percent of people feeling a lack of security from crime.
	Fire Protection	23) Change in incidence rates. 24) Change in rating of fire spread and rescue hazards.
	Recreation	25) Change in the number of people within or beyond a reasonable distance (x miles or y minutes) from recreational facilities, by type of facility. 26) Change in usage as a percent of capacity; waiting times; number of people turned away; facility space per resident; and citizen perceptions of crowdedness at recreational facilities. 27) Change in perceived pleasantness of recreational experience.
	Education	28) Change in number of students within x minutes walk or y minutes ride from school, by type of school. 29) Number and percent of students having to switch schools or busing status (from walking to busing or vice versa). 30) Change in crowdedness "breakpoints" (such as needed for added shifts) or indicators (such as student-teacher ratio); and student, teacher, and parent perceptions of crowdedness and pleasantness of schooling.
	Local Transportation	31) Change in vehicular travel times between selected origins and destinations. 32) Change in duration and severity of congestion. 33) Change in likelihood of finding a satisfactory parking space within x distance from destination or residence. 34) Change in numbers and percent of residents with access to public transit within x feet of their residences; and numbers and percent of employees who can get within x distance of work location by public transit. 35) Change in the rate of traffic accidents (or expert rating of change in hazard presented). 36) Number and percent of citizens perceiving a change in neighborhood traffic hazard; and change in pedestrian usage of streets, sidewalks, and other outdoor space.

Figure 7-7. Effects of land development and indicators for estimation. *(Continued on next page).*

	Shopping	37) Change in the number of stores and services, by type, available within x distance of people. 38) Change in the percent of people generally satisfied with local shopping conditions (access, variety, crowdedness).
	Housing Adequacy	39) Change in number and percent of housing units that are substandard, and change in number and percent of people living in such units. 40) Change in number and percent of housing units by type (price or rent range, zoning category, owner-occupied and rental, etc.) relative to demand or to number of families in various income classes in the community.
	People Displaced	41) Number of residents or workers displaced by development — and whether they are satisfied with having to move.
	Population Mix	42) Change in the population distribution by age, income, religion, racial or ethnic group, occupational class, and household type.
	Crowdedness	43) Change in the percent of people who perceive their neighborhood as too crowded.
	Sociability/ Friendliness	44) Change in frequency of visits to friends among people in the existing neighborhood, and frequency of visits between people in the existing neighborhood and the new development. 45) Change in the percent of people perceiving their neighborhood as friendly. 46) Number and percent of people with change in "visual" or "auditory" privacy. 47) Number and percent of people perceiving a loss in privacy.
Public and Private Services (Continued)	Overall Contentment with Neighborhood	48) Change in percent of people who perceive their community as a good place to live.

Source: Schaenman and Miller, November 1974.

Figure 7-7. (Continued).

change, has come to the forefront in recent years. From the above discussion, it is clear that transportation investments influence land use under certain circumstances. Empirical data suggests that transportation investments induce increased travel demand and worsen per capita emissions when they support development at the urban fringe (i.e., the location where the lowest density and highest travel consumption are found). From this it is inferred that transportation investments will improve per capita emissions when they create arrangements of land uses (i.e., higher density development that require less vehicular travel). This would be aided by the integration of transportation planning with land use planning.

However, the relationship between travel and land use is complex. For example, income accounts for a portion of travel variability with land use. In addition, insufficient data are available to determine causality, for example, whether low-density residential development "causes" people to have more vehicle travel or whether people with a proclivity toward extensive auto mobility select low-density areas for living. Regardless, the general interrelationships among transportation investment, land use, and air quality merit exploration particularly for those plans or projects that involve the urban fringe (generally high land availability/low land prices in an urbanizing area).

METHODS

There are a number of techniques discussed below that could support identification of cause-effect linkages between project impact-causing actions and goals and notable features. The techniques can be used individually or in combination. The techniques involve varying degrees of background research.

- *Matrices*—A project evaluation matrix is commonly a grid diagram in which two distinct lists are arranged along perpendicular axes, for example, actions and environmental characteristics. The interaction between actions and their environmental characteristics are noted in the matrix. Notation can be made in one of the following forms:
  - *Binary notation:* Only the presence or absence of an effect is indicated in the matrix through use of a checkmark or other device. This approach is the most straightforward and understandable but does not allow for notation of the magnitude of the impact or recognition of the importance of the resource relative to others in the matrix.
  - *Quantitative notation:* The magnitude, importance, duration, probability of occurrence, feasibility of mitigation, or other factors relating to the impact could be quantified and noted in the matrix. This method of notation requires a measurable quantity for all impacts. Differences in units used to measure various impacts must be clearly noted. Such differences may make it difficult to compare impacts.
  - *Weighted notation:* Relative ranking of impacts on a common scale allows for comparison of impacts, including summation into an overall ranking. A weighting scheme may also be designed to take the relative importance of each impacted resource into account.

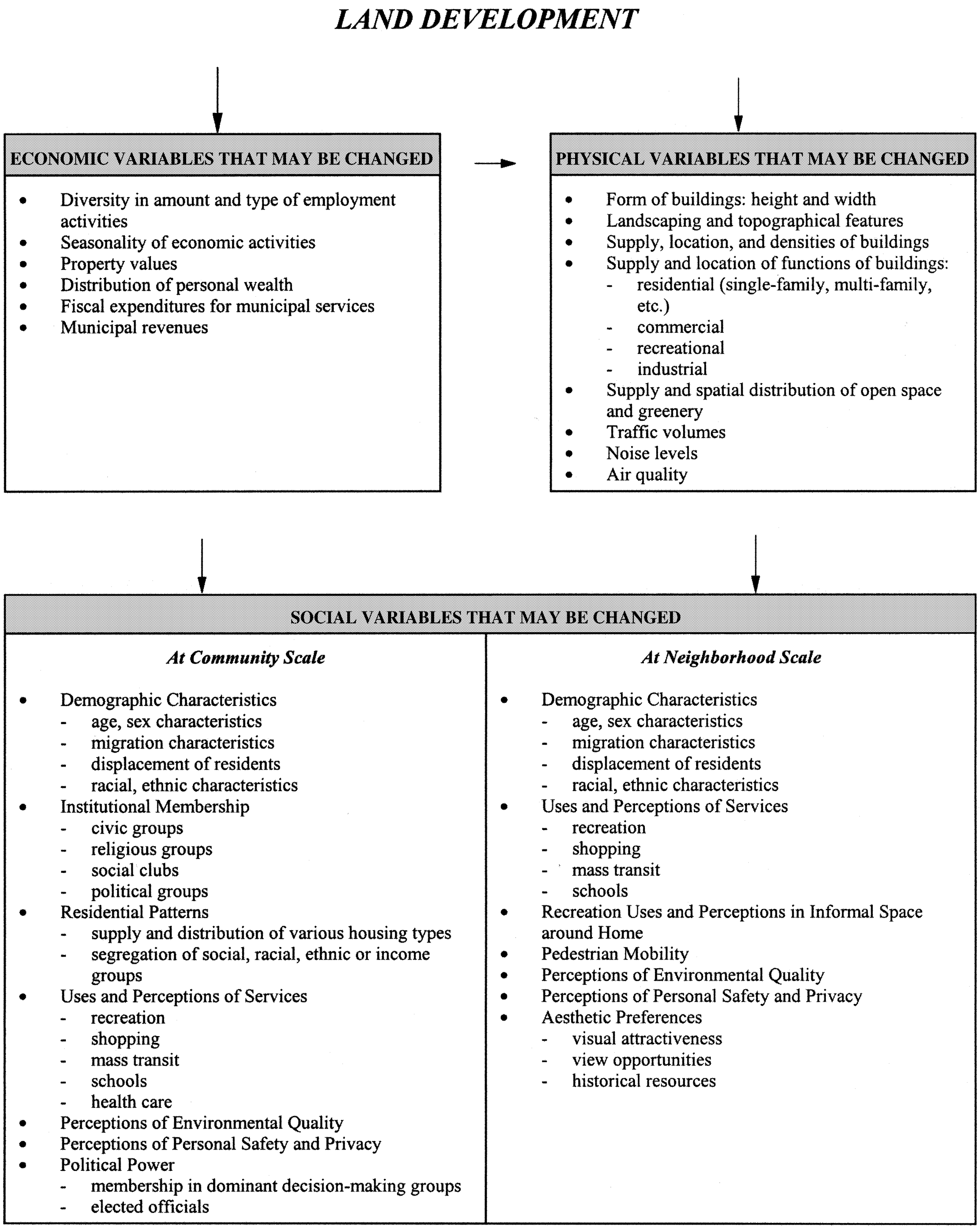


Figure 7-8. Possible effects of land development on socioeconomic variables.

Weighting schemes may be subjective in nature especially when comparing the value of impacted resources in relation to each other—the methods and criteria employed should be thoroughly reviewed and documented.

While a variety of techniques may be employed to identify indirect effects in addition to matrices, the final product of this step in the framework should be completion of the Evaluation Matrix attached as Figure 7-9 below.

- *Networks*—Also known as system diagrams, networks can be used in classifying, organizing, and displaying problems, processes, and interactions and to produce a causal analysis of the indirect effects situation. Obviously, the network is only as good as the as the underlying understanding or assumptions of often complex

Indirect Effect Type	Direct Effects from Impact-Causing Activities	Indirect Effects from Direct Effects (List)	Potential Manifestation of Indirect Effects (List)	Link between Indirect Effect and Goal or Notable Feature that Meets Impact Significance Criteria[1]	
				Yes (Go to Step 5)	No (Assessment Complete)
	Ecosystem-related				
Encroachment-Alteration	Socioeconomic-related				
		Serves specific development			
		Stimulates complementary development			
Induced Growth (Access-Alteration)		Influences location decisions			
			Ecosystem-related		
Effects Related to Induced Growth			Socioeconomic-related		

[1] Refer to Figures 7-10 and 7-11.

Figure 7-9. Evaluation matrix for potentially significant indirect effects.

processes and interactions. Networks often assume a strict hierarchical relationship among variables that may simplify more complex interrelationships. Network diagrams can include quantitative data in a fashion similar to the methods of notation describe for matrices. Information regarding probabilities may also be noted on network linkages and multiplied as one moves down the effects chain to reach the probability of tertiary effects.

The chains of indirect effects presented in Module 1 may be used as the basis for development of either matrices or networks suited to a particular project. Figure 7-10 provides an illustration of simple network diagram.

- *Qualitative inference*—This technique involves a case-study description of an area of concern (e.g., habitat or neighborhood) and an identification based on professional judgement of the possible changes that the proposed project would entail. The case study should focus on the elements or indicators that characterize the area of concern using ecological, economic, demographic, or social profile information from the baseline investigations in Steps 2 and 3. This technique, though practical and simple, has obvious limitations. Foremost among these is slipping into speculation based on limited data or unusual circumstances. Broad participation, including input from local planners, experts, or other stakeholders through surveys, interviews, or task forces can help avoid speculation.
- *Comparative case analysis*—Effects attributable to previously completed projects of a similar nature in similar circumstances can be studied for their applicability to the project under consideration. This comparative technique is described in detail in Module 8 below. Because it is difficult to find cases that are comparable in every respect, care should be taken not to rely exclusively on a comparative case for identification of effects. This technique can be a valuable supplement to other techniques outlined here.
- *Cartographic techniques*—Specific techniques, like the McHarg *overlay technique* (1969), which involves the combination of various feature and resource maps, are time-tested. These can be particularly useful for visualizing potential indirect effects related to alteration of the physical environment (e.g., habitat fragmentation or community segmentation). Computerized GIS have greatly enhanced the ability to process and display cartographic information. Cartographic techniques are limited in their ability to reveal the structure, function, and dynamics of areas. However, their utility can be expanded by relating inventoried information about these characteristics via a relational database.

Another cartographic technique applicable to identification of indirect effects is *resource capability analysis* (Rubenstein, 1987). Similar to the overlay technique, this process involves the preparation of two maps—an opportunity map depicting conditions favorable to development (topography, soil types) and a constraint map depicting areas unsuitable for development (wetland, floodplains, or other notable features identified in Step 3 [Module 5]). Overlaying the two maps produces a land

Context

Are there regional consequences of the effect?

Does the effect conflict with study area needs and goals?

General Considerations

Do transportation decisionmakers need to know about the consequences of simultaneous or subsequent development actions when considering the proposed project or plan?

(in other words.....)

Does a decision regarding the proposed transportation project represent a decision in principle about a simultaneous or subsequent development action?

Is the occurrence of the effect predictable?

Is the effect irreversible or of long duration?

Can the effect be controlled?

Is there a great deal of controversy related to the effect?

Could the effect result in a violation of federal, state, or local law, or other requirements imposed for the protection of the environment?

Will the effect have a significant impact on public health or safety?

A "yes" answer to any question above indicates that further analysis may be required. Proceed to Figure 7-11 Decision Tree for Assessing the Significance of Indirect Effects.

Figure 7-10. Impact-importance considerations for assessing potential significance of indirect effects.

suitability map indicating areas with capacity for potential induced growth. This map could be further modified to indicate areas with the highest potential for complementary development (interchange quadrants) and development shifts (interchanges and feeder roads) under the action alternatives.

ASSESSING SIGNIFICANCE OF IDENTIFIED EFFECTS

Not every identified indirect effect warrants further analysis. Some effects, although probable or reasonably foreseeable, would not be considered significant within the study area. Other effects, while potentially significant, could not be considered reasonably foreseeable or can not be analyzed with any specificity that would aid in the project decision-making process.

Considerations for assessing the significance of indirect effects are outlined in Figure 7-10 and a decision tree for assessing encroachment alteration effects and induced growth and related effects is presented in Figure 7-11. Considerations include impact location, magnitude, and importance. The goal of this step is to identify effects with enough specificity to reach a conclusion regarding significance.

In some situations, such as estimating the magnitude of induced growth effects where accessibility improvements are minor, it may be necessary to analyze effects more carefully before reaching a judgement regarding significance. In these cases, the techniques outlined in Step 6 (see Module 8) would be used to estimate the effects and the analyst would refer back to these considerations before a decision on the necessity of mitigation or enhancement is made.

APPLICATION TO PRACTICE

It is likely that some combination of the methods outlined above will be needed in most situations to identify the proposed transportation project's indirect effects. This combination would include cartographic techniques for spatial analysis; matrices or networks for visualizing systems' functions, behavior, and interconnections with the project; and either qualitative inference or comparative case study to support the visualization. Further considerations for systems planning or project evaluation are discussed below.

Transportation Systems Planning Context

All of the methods outlined above are applicable to the identification of indirect effects in the systems-planning stage of the transportation development process. Effects identified in this stage are necessarily broader in nature because project

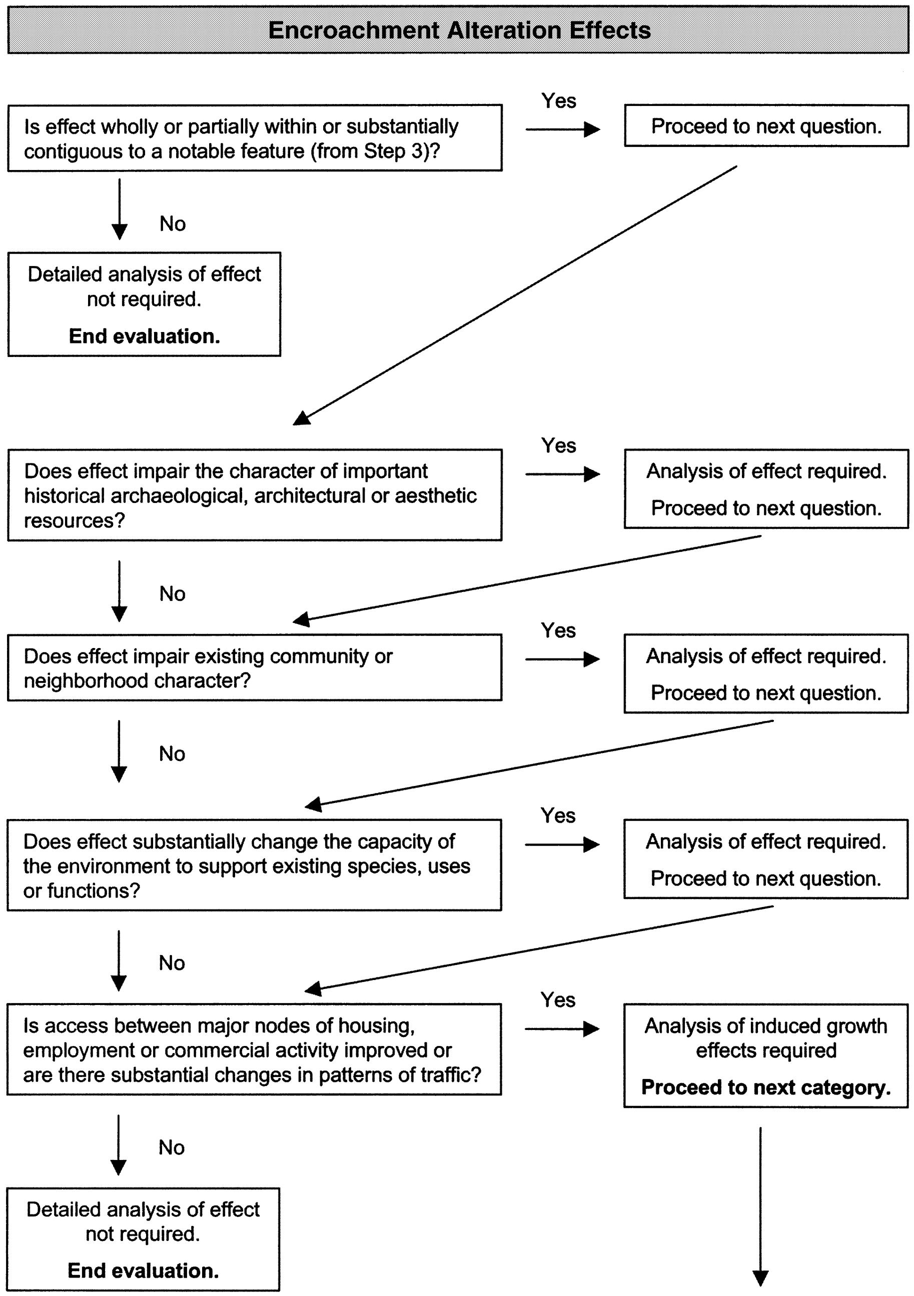


Figure 7-11. Decision tree for assessing significance of indirect effects. (Continued on next page).

design details are not fully developed. Induced growth and related effects arising from areawide increases in accessibility will, therefore, tend to be the focus of investigation.

An example of how methods can be combined to identify the full range of indirect effects discernable in the planning stage is given below.

- A simple matrix with binary notation can be drafted using professional judgement or lessons drawn from a review of the literature or similar cases encountered in the planning agency's jurisdiction or other areas. The matrix will show the range of potential indirect effects that can arise out of impact-causing activities identified during Step 4 (see Module 6). More complex effects can be illustrated with network diagrams.
- The validity of the matrix and the effects identified can be confirmed through consultation with a regional task force or through interviews with local planning agencies or experts. In project with major regional significance, it may be appropriate to conduct structured public involvement workshops. The need for local consultation and involvement will be guided by information on trends and

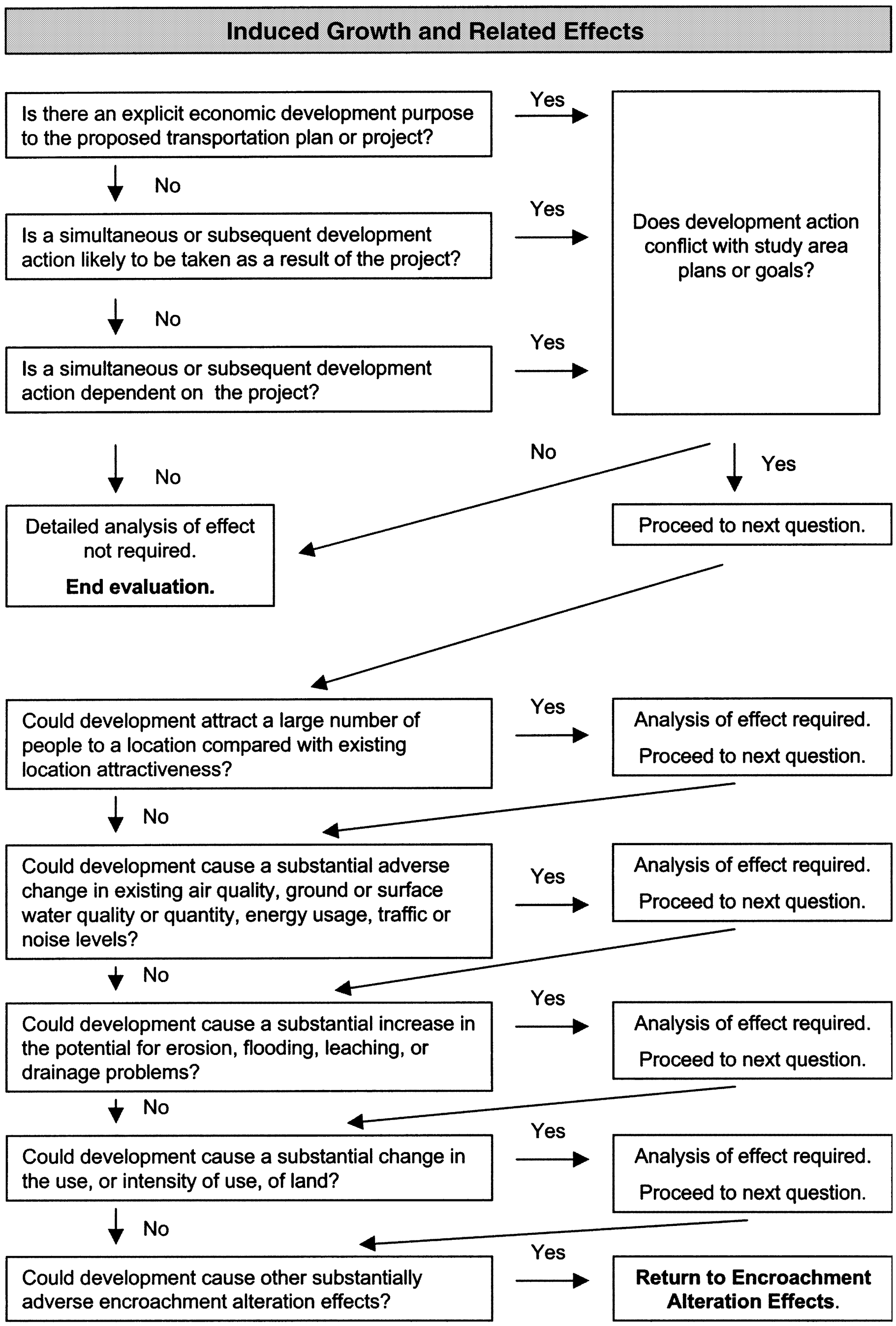


Figure 7-11. (Continued).

goals (Step 2), the location of notable features (Step 3), and whatever information is available on project impact causing activities (Step 4).
- GIS, resource capability analysis, and overlay techniques can be combined to produce maps noting the location of the following elements:
  – planned transportation improvements
  – conditions favorable to development
  – constraints to development (physical and regulatory)
  – notable features
  – areas likely to be the focus of changes in accessibility and therefore complementary development or development shifts.
- The matrix and the mapping exercises should be carefully examined to identify effects meeting the criteria for significance (magnitude and importance).

Project Evaluation Context

The methodology for identification of indirect effects during the NEPA evaluation of a project would be similar in every respect to the process described for the systems-planning phase. Matrices, network diagrams, inference and consultation techniques, and cartographic techniques can be combined for a thorough evaluation. The greater detail on project features and impact-causing activities available at this phase allows for greater specification of effects, particularly encroachment/alteration effects. For more complex projects, it may be appropriate to quantify or weight effects in a matrix so that magnitude can be assessed and comparison of effects can be conducted. Similarly, more detailed mapping of project features that could produce encroachment or induced growth effects will reveal areas of susceptibility to change or conflict with notable features.

WORK PRODUCT OF STEP 5

Regardless of the method or combination of methods employed, tabulation is necessary to organize the information gathered and to make explicit the process used to determine which indirect effects should be carried forward to detailed analysis. Figure 7-9 presents the framework of a table designed for this purpose. A completed table would also indicate the results of an evaluation for significance outlined above.

A technical memorandum should be prepared that lists the indirect effects that warrant further analysis, if any, and presents the scope of detailed analysis. The technical memorandum should contain relevant documentation supporting the list of identified indirect effects (e.g., checklists, networks, maps, etc.) as well as documentation on those indirect effects considered but dismissed from further analysis by agreement of the involved parties.

RESOURCES AND SUPPLEMENTARY READINGS

Gramling, R., and Freudenburg, W. R. “Opportunity-Threat, Development, and Adaptation: Toward a Comprehensive Framework for Social Impact Assessment.” *Rural Sociology,* Vol. 57, No. 2 (1992).

Incorporating Biodiversity Considerations into Environmental Impact Analysis Under the National Environmental Policy Act. Council on Environmental Quality, Washington, D.C. (1993).

McHarg, I. L. *Design with Nature.* Natural History Press, Washington, D.C. (1969).

Rubenstein, H. M. *A Guide to Site and Environmental Planning.* John Wiley & Sons, New York, NY (1987).

Schaenman, P. S., and Muller, T. *Measuring Impacts of Land Development: An Initial Approach.* The Urban Institute, Report No. URI 86000 (November 1974).

COURSE MODULE **8**

STEP 6—ANALYZE INDIRECT EFFECTS

OVERVIEW

Step 5 of the framework illustrated how to identify potentially significant indirect effects. This process of describing the cause/effect relationships between the project and the range of potential impacts to study area goals and notable features provides the foundation for Step 5, the analysis of the potential indirect effects. The objective of this step is to assess the significance of the effects identified in the previous step by determining magnitude, probability of occurrence, timing and duration, and degree to which the effect can be controlled or mitigated.

A variety of quantitative and qualitative tools can be employed in the analysis of potential indirect effects. This module will

- Describe the tools available,
- Outline steps involved in using the tools for indirect effects analysis,
- Detail sources for further information regarding each tool, and
- Suggest combinations of tools and steps for basic and detailed analysis applications for systems planning and project evaluation.

CONSIDERATIONS

The first step in the analysis of potentially significant indirect and cumulative effects is to assess the potential and magnitude of project-influence effect. A discussion of the types of induced growth and how such growth is related to the proposed transportation improvement is discussed above in Module 7.

Once the level of induced growth has been assessed, impacts on the natural environment arising from development can be evaluated. Encroachment-alteration effects arising from the project itself should also be assessed after induced growth impacts are explored so that these alteration effects can be fully understood in the context of future land uses.

Analyzing induced growth is an exercise in creating and comparing forecasts of future conditions. At least two forecasts are necessary: (1) a Base or No-Action Forecast, which describes future conditions in the absence of the project or plan, and (2) an Action Forecast describing conditions in a future point in time following implementation of the project alternative or plan.

These forecasts can also be designed to fully consider cumulative effects by including significant past and anticipated actions undertaken by other parties in both the base and project scenarios.

The key in forecasting is an underlying system of logic that can produce reproducible and relatively consistent results regardless of the forecaster. It should be noted that forecasting is not the exact determination and prediction of the future, but the logical extrapolation of likely effects that will occur from known associations among different critical parts of the system.

As with other steps in the framework, induced development forecasting techniques may be either qualitative or quantitative in nature:

- Qualitative methods can serve to evaluate the context or overall situation wherever little historical data exist or wherever existing data are questionable or inconsistent.
- Quantitative methods consist of modeling or the search for causal factors, and extrapolation or emphasis on time series.

Whenever possible, forecasts developed for other purposes by regional planning and transportation agencies should be used. Use of established forecasts as control totals or baselines will not only reduce the level of effort required in the assessment but will also promote acceptance of the findings.

A variety of qualitative and quantitative methods are described below. Examples of how these techniques can be combined and applied to potential planning and project scenarios are addressed at the end of this module.

QUALITATIVE FORECAST TOOLS

Literature Review/Comparative Case Analysis

There is a small but growing body of literature concerning the induced development effects of transportation projects, and other indirect effects such as economic benefits to industry arising from increased access and the economic loss to main street business in bypass projects. This literature could be useful in developing sketch scenarios for smaller projects. The literature could also point to instance of comparable cases that merit further study.

A comparative study involves comparing a like area where a similar project has been completed with the area of concern where a project is proposed. There are several important considerations when employing this method:

- The two projects and areas must be similar in size, project type, location, and design. Demographic conditions, growth rates, and other pertinent characteristics must be comparable.
- Data sources for the two areas and projects should also be similar.
- Study of the like area essentially consists of beginning with a *retrospective analysis* (or case history) in which adequate information regarding conditions in the area prior to the project would need to be obtained. Although some of this baseline information can be found in available sources such as an EIS, this information may not match the data requirements. In other words, the retrospective analysis estimates conditions that no longer exist, a task that may not be easier than predicting conditions which do not yet exist.
- Retrospective analyses involve separating project-related impacts from those caused by other factors.
- A number of effects that may eventually occur because of the transportation project may not have yet occurred (e.g., because of an economic downturn).

Comparative case analysis entails a double effort for data collection and assumes that the proposed project has an accessible twin. Even if similar circumstances can be found, the results may differ because of various random and non-random effects. Objectives and policies, for example, tend to change over time. While it would be preferable to compare the proposed project with several analogous cases, this would entail more resources. It is obvious that caution must be used in implementing comparative case analysis. However, comparative case does have potential for improved identification of indirect effects that are otherwise difficult to identify.

Scenario Writing

Scenarios are an outline in narrative form of some conceivable future environment given certain assumptions about the present and a sequence of events in the intervening period. Multiple scenarios can be drafted to include a variety of changing conditions, a spectrum of potential developments, and a series of hypothetical sociopolitical, ecological, and economic consequences of proposed actions.

Rather than predictive, scenario writing is a technique that attempts to establish some logical sequence of events to show how, under present conditions and assumptions, a future environment might evolve. Scenarios can also serve to set the upper and lower bounds of potential outcomes.

A particular difficulty in scenario writing is consideration of the various uncertainties in forecasting arising from long-range, future-oriented planning. Included are broader uncertainties about the external planning environment; future intentions of other decisionmakers; appropriate value judgements; and institutional and social changes. Another difficulty is in uncovering a variety of variables that may not be apparent in the present but which may be of significance in future environments.

There are obvious questions regarding the extent of completeness, validity, or overall accuracy or reliability of scenarios. Effective scenario writing requires continuous questioning of the values, insights, assumptions, and level of information of the scenario writer(s). The level of confidence in scenario writing, therefore, depends on both the plausibility and credibility of the argument, and on the competence and qualifications of the scenario writer(s).

Delphi Technique/Expert Panel Survey/ Public Involvement

Thorough surveys of local experts, stakeholders, and professionals can be invaluable in developing assumptions and assessing future conditions. Survey techniques include informal conversations; formal inquiry following an instrument administered by mail, phone, or interview; or discussions or meetings of a collaborative task force or panel. The most structured consultation method is the Delphi technique. Delphi is a survey research technique directed toward the systematic solicitation and organization of expert intuitive thinking from a group of knowledgeable people (Linstone and Turoff, 1975). It provides a means for arriving at an informed, objective judgement based on a variety of sometimes conflicting opinions. Rather than achieving consensus by open discussion, Delphi uses a carefully designed program of sequential individual interrogations interspersed with information and opinion feedback derived from consensuses which are computed from earlier parts of the technique.

Figure 8-1 shows the logical sequence of a typical Delphi study and its series of questionnaire rounds. The issues must be structured carefully to bring out the most important questions. This technique provides sensitivity for potential futures and opinions for delineating probable future actions. It can be used to obtain expert opinion on cause and effect relationships and related probabilities when adequate models are not available. Skilled facilitation is required to elicit the experts' opinions. Selection of experts and methods to avoid means of influencing opinion are other important elements of Delphi.

While this technique is less well defined and requires more expert direction than other detailed qualitative techniques, it can develop ideas and identify causal relationships that might not surface in more structured methods. There are several examples of the technique's application to practice. Recently the Texas DOT used the Delphi method to allocate population and employment control totals to Traffic Analysis Zones

Activity	Round 1	Round 2	Round 3
Type of data and information	-Broad trends, events developments	-Agreed developments from Round 1 -Newly suggested items	-Narrowing of items from previous rounds -Detailed analysis of selected trends, events, and developments
Inquiry	-When might these take place?	-When might these occur? -Under what conditions? -Justification of extreme views	-Reasons for consensus or non-consensus -Reasons for time estimates -Likelihood and severity of consequences
Analysis	-Collation of statements -Configurations of first agreements -Analysis of commentary	-Summary of selections -Estimation of median -Any additional considerations	-Tabulation of major consequences -Range of agreement -List of selected threatening and desirable items
Suggestions	-What other developments can be suggested? -What is the level of the participant's expertise?	-What major technological and societal consequences may result?	-What can be done to alleviate or mitigate effects? -Reestimates for time horizon or other comments

Figure 8-1. Delphi study process.

(TAZ), in order to evaluate the potential development effects of transportation improvements (Gamble, 1993).

Expert panels or detailed interviews with local real estate, government, and industry leaders may be a workable substitute for the Delphi method when panelists would be unable to participate in an iterative process. Less formal methods lack the feedback and review features of Delphi, but may be used to construct or confirm assumptions employed in other qualitative or quantitative techniques. Project task forces made up of a representative mix of community stakeholders can also help define and refine forecasts techniques and results especially when coupled with public outreach meetings or charettes designed to gauge the range of community expectations regarding project induced growth. Task force and outreach techniques can also serve to build consensus that would promote broad acceptance of findings.

QUANTITATIVE FORECAST TOOLS

Trend Extrapolation

Trend extrapolation is a commonly used method of projection, based on the analysis of time series data. The technique requires holding the assumption that the factors that contributed to the trend in the past are more likely to remain constant than to change in the time period of future consideration. Future baseline estimates of population, employment, housing starts, and other conditions can be predicted using this method. There are a number of trend extrapolation techniques including:

- Simple (straight line) extrapolation—finding a line which best fits a plot of time series data and using the linear equation for that line to project data points in future periods;
- Curve fitting (polynomial, exponential)—finding a curve which best fits a plot of time series data and using the equation for that exponential relationship to project data points in future periods; and
- Asymptotic (upper limit) curves—finding a curve which best fits a plot of time series data with an upper limit on data values; the limit function equation allows for projection of the curve into the future as it approaches an upper limit.

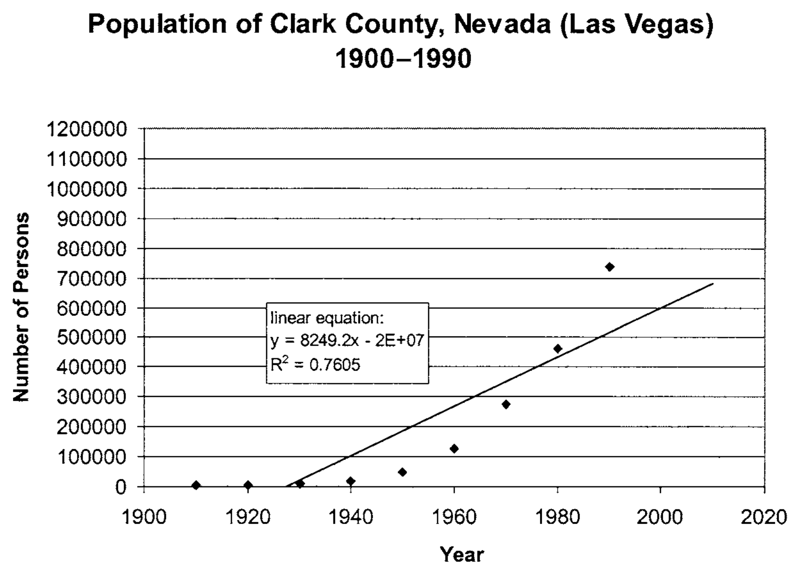
Choice of an extrapolation technique requires judgement based on the data and the situation. For example, exponential curve fitting is best applied to areas growing at a rapid rate. Envelope or asymptotic curves should be employed when known limits on scarce resources such as available land, or sewer and water infrastructure, would inhibit future growth. See Figure 8-2 for examples.

Once the data have been gathered, trend extrapolation projections can be prepared with little effort using standard automated functions of spreadsheets, statistical packages, or other data processing software.

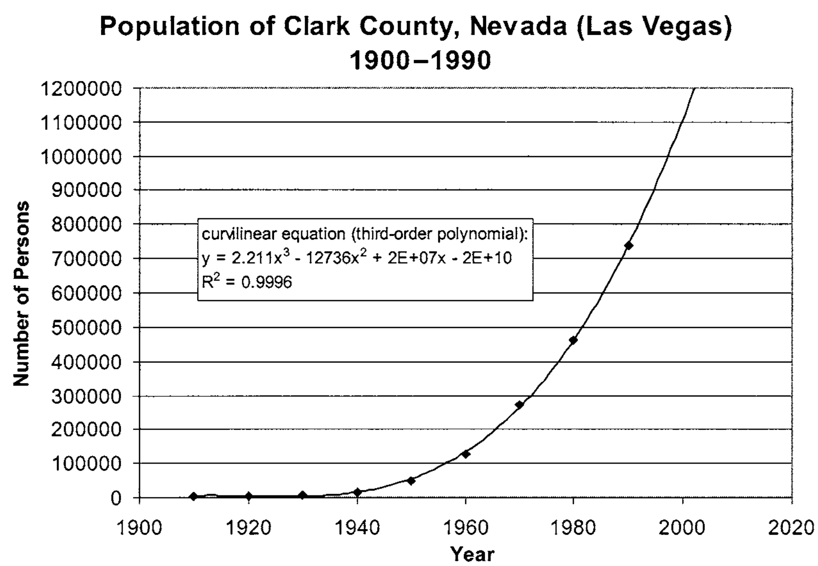
Trend extrapolation techniques are limited in their application to indirect effects analysis, because the techniques are only useful in creating base case or no-action forecasts—extrapolation is not helpful in evaluating project alternatives that will by definition change conditions on which historical trends have been based. This type of forecasting technique is also unnecessary when accepted forecasts have already been developed by local or regional agencies for the study area.

Trend extrapolation techniques have been criticized for being too simplistic. Other drawbacks include the following:

- Projections taken out too far into the future (more than 5 years) or based on too few historical data points may be seriously flawed.

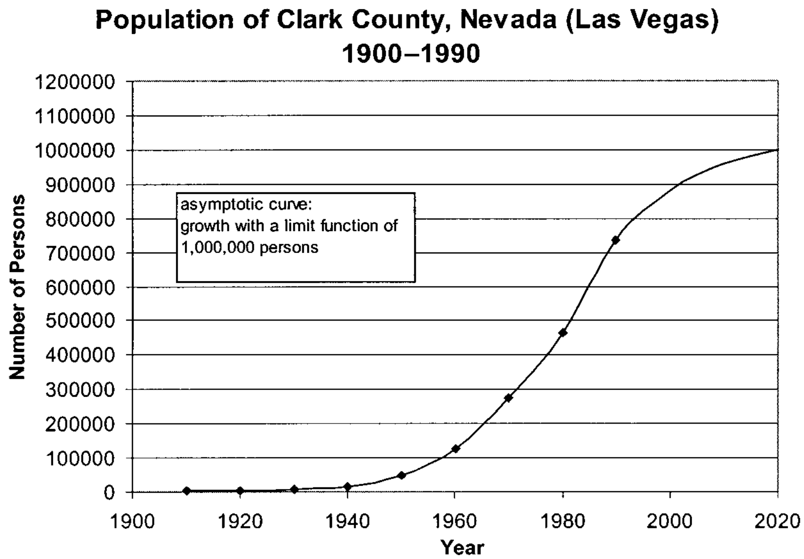


Linear Equation: The linear equation is not the best fitting curve in circumstances where growth is exponential.



Curvilinear Equation: A polynomial equation provides the curve with the best fit to the data but projection of the high rate of growth in the past to the future may not be realistic.

Figure 8-2. Examples of trend extrapolation. (Continued on next page).



Asymptotic Curve: Using a limit function to constrain growth to an upper limit may be more consistent with reality but the accuracy of the projection will be entirely dependent on the accuracy of the limit that has been set. The constraint, therefore, should be based on a factor that would reasonably be expected to curtail growth, such as the carrying capacity of land, or limits of the water supply.

Figure 8-2. (Continued).

- The assumption that conditions supporting past trends are unlikely to change is often unrealistic in an age when technology and public opinion can undergo rapid shifts.

Despite these drawbacks, trend extrapolation can serve indirect effects analysis best when, after the trend has been projected, there is detailed exploration of factors supporting continuation of the trend and factors or developments that will alter, limit, or violate the projected trend.

Build-Out/Carrying-Capacity Analysis

At some point in a quantitative forecast exercise for indirect effects, it is necessary to relate projections of population and employment with consumption of land. Unless this step is integrated into the process, as it is with many formal land use models, the analyst must determine standards for land consumption by land use. (Population can be related to land use by determining the number of units per acre and the average household size; similarly, employment can be related to land use by using standards of employees per square foot or per acre for various types of commercial development; see Figure 8-3 for example standards). The goal is to compare how land consumption will differ with and without the proposed transportation improvement.

In areas with established land use controls, the analyst can

- Develop a no-build scenario by analyzing current regulation and anticipated plans, keeping in mind historical trends in the granting of variances or passage of changes to the zoning ordinance,
- Determine the carrying capacity for each zone and determine when build-out is likely to be achieved,
- Determine if the timing of development is likely to be influenced by the build-alternatives using other quantitative or qualitative techniques described here, and
- Determine if the build alternatives are likely conflict with land use regulations or create development pressures that may result in revision of land use regulations assumed in the no-action scenario.

In areas where land use is not widely controlled or where population projections have not been related to land consumption, it may be necessary to develop a no-action future scenario from scratch using assumptions about location choices and land consumption with and without the transportation improvement. These scenarios can be developed using any of the other quantitative or qualitative techniques described here.

Regression Analysis/Econometric Forecasting Techniques

Trend extrapolation techniques are used to determine how one dependent variable (such as population, household size, or number of building permits issued) has varied with a single independent variable (time) in the past, so that a prediction may be made about the future. Regression and econometric

Residential Land Uses
Where available densities permitted in applicable zoning or development regulations should be used. The table below illustrates typical values.

Housing Type	**Units (Households) Per Acre**
Rural Single Family Dwelling (SFD)	0.25
Low Density SFD	1.00
Conventional SFD	3.00
Small Lot SFD	5.00
Townhouse	10.00
Garden Apartment	15.00
Mid-Rise Apartment Building	15.00
High-Rise Apartment Building	60.00
Mixed-Use Building	12.00

Non Residential Land Uses
Where available, Floor Area Ratio (FAR) permitted in development regulations should be used in place of typical numbers used below.

Structure Type	Square Feet per Employee	Average Building Size	FAR	Average Lot Size	Average Number of Employees/Acre
Office	333	25,000	0.40	1.43	52.32
Retail	400	10,000	0.20	1.15	21.78
Warehousing/Distribution	667	10,000	0.25	0.92	16.33

Transportation
Streets can be assumed to account for 17% of gross land area for all land use types.

Figure 8-3. Typical values for land consumption by land use type (source: Social Cost of Alternative Land Development Scenarios [SCALDS] model, FHWA, 1989).

techniques allow a forecaster to explore the relationship between a dependent variable and several independent variables, either in time-series or cross-section to predict future events. Although many forms of regression analysis may be employed in forecasting, as an example, we will discuss ordinary least squares regression.

The first step in regression analysis is to establish a hypothesis regarding the relationship of a dependent variable such as population to the various independent variables for which data are available at the proper level of aggregation. This hypothesis takes the form of a linear equation. For example, to forecast population growth one could hypothesize that population in a zone is a function of accessibility to employment centers in other zones, land zoned for residential use, housing costs, availability of water and sewer service, and crime rates. The linear equation matching this theoretical model would be:

$$P_j = \beta_0 + \beta_1(A_j) + \beta_2(L_j) + \beta_3(H_j) + \beta_4(W_j) + \beta_5(C_j) + \varepsilon$$

where

P_j = Population in zone j
A_j = Average travel time to major employment centers
L_j = Acres zone for residential use
H_j = Average unit purchase cost for housing
W_j = Presence of water/sewer service
C_j = Crime rate per thousand persons
β_0 = Constant (intercept)
β_x = Coefficient (slope)
ε = Error term

Undertaking a regression analysis and evaluating the statistics produced for an equation like the one above allows the analyst to

- Determine how well the independent variables explain the variation in the dependent variable (R^2 statistic explains the proportion of variability explained by the model);
- Obtain an indication of relative importance of each variable in the model (t-statistics indicate the strength of the contribution and can be used to determine whether the contribution is significant–insignificant variables should be dropped from the model); and
- Predict the independent variable for any given value of the dependent variables (through application of the coefficients in the equation).

Good data and a well-formed model could be used to predict changes in population or employment in an area based on changes in accessibility arising from a project alternative. This would be achieved by varying the accessibility component of the equation while holding other variables constant. Regression analysis could also be used to determine the relative weights of variables determining location attractiveness to be used in a gravity model equation (see below).

Simple Gravity Model

Gravity models follow from the observation that the attractiveness of a location as destination for travel is a function of its "mass" (measured in square footage, for example) and the distance to other similar regional destinations. As in the formula for gravitational attraction used in physics, distance, the denominator, is squared or raised to the power of another exponent to represent its greater importance when compared to mass.

This formulation of mass over distance can also be adapted to predict the location of future concentrations of households or employers as regional accessibility changes. This method allocates predetermined growth in employment and population for a study area to subareas based on mass (the presence of attractors such as population, employment, vacant land, and other factors) and friction (distance between attractors in travel time). Control totals used for allocation can be developed using other forecasting techniques or preferably the totals can be based accepted forecasts developed by state or regional planning agencies.

The process described below is a very simplified version of some of the more sophisticated integrated land use and transportation models. In this formulation, the allocation of employment is conducted first and then population is allocated based on employment location. The results derived can be expected to be less accurate than output from formal, calibrated models, but can be used to indicate trends and supplement qualitative analysis based on interviews with local experts. Steps involved in one version of the gravity model are described below (Adapted from Krueckeburg and Silvers, 1974).

Step 1: Allocate Employment Control Totals to Zones

Step 1A: Determine index of accessibility for each zone

The accessibility index (*Aj*) for a zone *j* is calculated as:

$$A_j = \sum P_i / D_{ij}^{\lambda} \qquad i \neq j$$

where

P_i = Population in each other zone i
D_{ij} = Time distance from zone j to each other zone i (from travel model)
λ = exponent related to friction factor (2, or derived from observation)

Step 1B: Determine employment growth in each zone

Employment growth in each zone (*Gj*) is calculated as:

$$G_j = G_t\left(L_j A_j / \sum L_i A_i\right)$$

where

G_t = Growth in employment in entire study area (determined exogenously)
L_j = Land (space) available in zone j
L_i = Land (space) available in each zone i

Step 1C: Add employment growth to employment totals and subtract some measure of available land utilized (either estimated or observed) by this growth from L_j.

Step 2: Allocate Population Control Totals to Zones

Step 2A: Determine index of accessibility for each zone

The accessibility index (*Aj*) for a zone *j* is calculated as:

$$A_j = \sum E_i / D_{ij}^{\lambda} \qquad i \neq j$$

where

E_i = Employment in each other zone *i* (new totals from Step 1)

Step 2B: Determine population growth in each zone

Population growth is calculated by using the same formula described in Step 1B, substituting estimated growth in population for the study area (G_t), and the new measure of accessibility to employment (A_j).

Step 2C: Add population growth to population totals and subtract some measure of available land utilized (either estimated or observed) by this growth from L_j.

The steps could be repeated for 5-year intervals or for any other period where the exogenous predictions of overall growth in employment and population are available.

Other factors that contribute to the attractiveness of a location to employment or population could be added to the equation. These factors include land value, availability of infrastructure such as water and sewer, and quality of life measures such as housing condition and crime. When adding other factors to the model, care should be taken to establish the relationships between the variables by assigning weights. Weighting can be achieved by using a regression model to determine the importance and significance of factors or by surveying stakeholders or local experts.

Policy considerations could be accounted for by modifying the available land variable (L_j) to take into account zoning, use, density, and conservation area restrictions. Calculating this variable would involve decisions or assumptions about environmental and physical constraints (wetlands, slope, brownfields) and may require use of GIS analysis to cull and sum up vacant parcels or portions of parcels in each zone.

Economic and Fiscal Impact Modeling/ Cost-Benefit Analysis

The construction and operation of transportation facilities often result in direct economic and fiscal impacts. These direct impacts include the temporary increase in employment attributable to construction, the increase in business to local suppliers as construction materials are purchased, the increase in productivity as travel costs are reduced, and the loss of local property taxes resulting from the acquisition of right-of-way. There are other, indirect economic and fiscal impacts, however, that may be accounted for in the assessment of proposed transportation improvements. Examples of indirect impacts include the following:

- The multiplier effect generated as direct expenditures on construction and maintenance materials increase demand for raw materials and intermediate products throughout the local and regional industry supply chain,
- The multiplier effect generated as local construction and maintenance employees spend wages on consumer goods,
- The direct and indirect impacts of the decline in economic activity as traditional business areas are bypassed by a new transportation facility,
- The direct and indirect impacts of an increase in economic activity as new business are developed to serve the increase in traffic attributable to a transportation improvement,
- The direct and indirect impacts of an increase in tourist activity resulting from gains in accessibility attributable to the transportation improvement,
- The direct and indirect impacts of an increase in economic activity as other businesses are attracted to the area by gains in accessibility and productivity attributable to the transportation improvement,
- The fiscal benefits (increase in property taxes) resulting from a rise in property values attributable to project induced growth, and
- The adverse fiscal impacts (increase government spending) resulting from the greater need for services (infrastructure, schooling, public safety) attributable to project induced growth.

Although it is generally possible under most circumstances to estimate the construction and maintenance impacts described above, it is often more difficult to quantify the economic/fiscal benefits and costs of project-influenced growth or increased accessibility. To the extent that project-induced growth is quantified using other techniques described in this module, however, it would be possible to use a common set of economic and fiscal impact tools to estimate these types of potential effects.

Because the direct and indirect economic impacts attributable to proposed transportation improvements are closely intertwined, it will often be useful to analyze them simultaneously. There are four broad categories of direct and indirect impact measures to consider when evaluating project alternatives in a cost-benefit framework (*TRB Circular 477*, 1997).

User Impacts

The value of each of the following measures may be combined to measure total impact:

- money cost of travel
- travel time
- safety
- comfort, reliability, and so on.

User impacts are most often direct in nature, so they will not be covered in detail here. User impacts are best measured through transportation demand models.

Economic Impacts

Each of the following measures is an alternative way to express total impacts, the measures are not additive:

- employment
- personal income
- business sales volume
- property values
- value added
- business profit

Economic impacts can be direct and indirect in nature. Direct impacts are attributable to spending on construction and maintenance itself. Indirect and induced impacts are attributable to project induced growth and the multiplier effects arising from direct spending.

The user and economic impacts are not additive. The user benefits directly from the travel time savings, safety, and comfort of a new transportation project, while the economic benefit of increased property values is an indirect impact of the project. The *Transportation and Traffic Engineering Handbook* (Institute of Traffic Engineers, 1985) provides a good example by discussing *Real* versus *Pecuniary* benefits. *Real* benefits accrue to the final consumers of a project, while *pecuniary* benefits accrue to some individuals at the expense of other individuals. In the case of increased property values resulting from improvements to the transportation system, the owners of the property will benefit from these improvements, while the consumers of the property will pay higher rents or acquisition costs.

Basic methods to measure direct and indirect economic impacts include the following:

- *Input/Output Models*—These models rely on accounting tables (produced and updated on a 5-year basis in the United States by the Bureau of Economic Analysis) that describe the linkages of interindustry purchases and sales. With certain modifications, the data can be tailored to provide information applicable to a specific region. The models yield multipliers that show the full effect on all industries as final demand for the products produced by a proscribed set of industries (those involved in highway construction, for example) is increased or decreased. The multipliers allow for calculation of the direct, indirect, and induced output (sales), earnings (wages), and employment (full-time equivalent jobs) impacts. Models are commercially available from the Minnesota-based IMPLAN Group, the Regional Science Research Institute (PC I/O Model), the U.S. BEA (RIMS-II) and many transportation planning consulting firms.
- *Macroeconomic Simulation Models*—These models include the function of I/O models described above and additional features used to forecast the effects of future changes in business costs, prices, wages, taxes, productivity, and other aspects of business competitiveness and shifts in population, employment, and housing value. As with I/O models, these methods can be used to evaluate the consequences of factors beyond travel costs impacts such as project-induced growth, if the growth impacts are quantified with techniques exogenous to the model. Simulation models are available for rental, purchase, or custom studies. Examples include REMI (Regional Economic Models Inc.) and DRI-McGraw Hill.
- *Business Market and Tourism Attraction Studies*—Specific factors unique to the study area can contribute to the attraction of businesses and tourists. Business factors such as proximity to suppliers, markets, and other modes of transportation, and tourist factors such as proximity to unique existing or proposed recreation, historical, or commercial amenities must be studied in detail to assess the potential for attraction that may improve with the accessibility attributable to the proposed transportation improvement.

Government Fiscal Impacts

The value of each of the following measures may be combined to measure total impact:

- public revenues
- public expenditures

Fiscal impacts arising from induced growth and land use changes attributable to transportation improvements can be calculated by using the analysis method described in this module for assessing induced growth combined with standard fiscal impact methodologies. Once the range of potential growth outcomes has been quantified, service standards describing the cost of providing additional infrastructure, education, emergency services, and other government functions can be applied to determine costs. The calculation of benefits must rely on assumptions based on the current profile of property taxes and ratables.

The recently developed SCALDS model (Social Cost of Alternative Land Development Scenarios) available through FHWA provides a framework for applying the fiscal costs and benefits related to transportation improvements. The model is described in more detail under the section "Integrated Transportation and Land Use Models."

Other Societal Impacts

The value of each of the following measures may be combined to measure total impact:

- air quality
- impact to environmental features
- change in societal conditions

Air quality impacts studies are most often limited to the direct impacts attributable to the proposed transportation improvement. The SCALDS model (described in more detail below) provides a framework for assessing air quality impacts related to induced development. Impacts to other features can be estimated using the other techniques described in each step of the indirect effects analysis framework.

Integrated Land Use and Transportation Models

Transportation planners have long relied on computer-based models to predict how traffic patterns change with improvements to the transportation system. In the last two decades, there have been an increasing number of models that also predict the indirect land use effects of transportation projects—land development and the location of households and employers. To properly simulate the relationship between land use and transportation, integrated models are required. These models predict how changes in accessibility influence changes in location and how the congestion created by relocated households and businesses, in turn, affects accessibility. Several approaches have been employed to simulate locational decisions but it is the feedback between the transportation and land use components of these models that make them integrated and useful in the analysis of indirect effects.

Since the early 1990s, computer modeling of land use patterns has become more sophisticated. In recent years, developers have undertaken improvements in the feedback loop between travel demand and land use components, have improved the process of calibration, and have added GIS software as a graphical interface for data input and output. Even the more complex computerized models now run quickly on standard desktop computers. This increased sophistication and improved usability has contributed to wider use of models at state agencies and MPOs.

A 1995 study described the results of a survey of model use at MPOs in the 35 largest metropolitan areas. Eighteen of the 35 employed or were planning to employ modeling techniques at the time of the survey: twelve indicated that they use one of the models discussed below (DRAM-EMPAL); another six have developed or are developing their own models. The remaining MPOs employed qualitative techniques including the Delphi method to allocate forecasted population and employment (Porter, 1995).

This section examines integrated land use and transportation models that are currently available for implementation. Several reviews of formal land use models and their integration with travel models have been published in recent years. This section is based in large part upon three recently published reviews: *Land Use Impacts of Transportation: A Guidebook* (*NCHRP Report 423A*, 1999); *Review of Land Use Models and Recommended Model for DVRPC* (Oryani and Harris, 1996); and "Operational Urban Models: State of the Art" (Wegener, 1994). Several other papers have been published on the importance and utility of transportation/land use modeling and are cited below. A summary of the features and requirements of the models discussed (see Figure 8-8) appears at the end of this section. A list of references appears at the end of the module.

ITLUP (DRAM/EMPAL)

Developed in the 1970s by University of Pennsylvania's Steven H. Putman under contract with the U.S. DOT, the Integrated Transportation and Land Use Package (ITLUP) is the most widely used model for land use forecasting among transportation agencies (see Figure 8-4). Because of its data and time intensive nature however, it is most often employed by larger agencies.

ITLUP forecasts population growth and household location in zones based on the Lowry gravity- model method. The software consists of two major submodels: DRAM and EMPAL. DRAM (Disaggregated Residential Allocation Model) estimates household location by household type (income quartiles) in relation to employment locations in a future year and the probability of work trips between zones in that year. Travel between zones is based on transportation impedance (time or cost) and a measure of attractiveness for each zone based on the availability of land, the percentage of households by income quartiles, and the location of employment. The location of employment can be derived through EMPAL (Employment Allocation Model) or through assumptions made outside the model. Another submodel, LANDCON calculates the consumption of land associated with the household and employment forecasts. Model calibration is achieved through an automated program (CALIB) that estimates equation coefficients and provides goodness-of-fit statistics, asymptotic *t*-tests for the statistical significance of the coefficients, and point elasticities for sensitivity analysis (DVRPC, 1996).

Travel models provide the input for zone to zone travel impedance and ITLUP is capable of interfacing with all the major

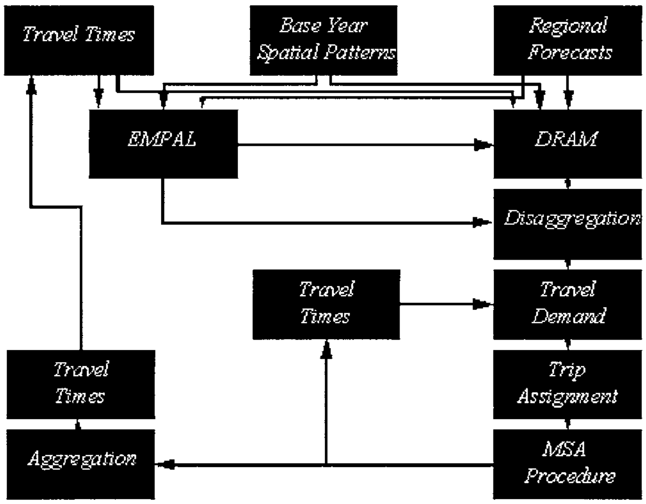


Figure 8-4. Structure of ITLUP (source: Oryani & Harris, 1996).

travel model packages in use today, including TRANPLAN, EMME/2, and MINUTP. The model can also be adapted to read any travel impedance matrix generated by custom packages. Through its interface with travel models, ITLUP allows users to estimate the induced land use impacts of transportation improvement projects. ITLUP can be run for several different improvement scenarios, showing the impact of zone to zone accessibility changes on the location of employment and households. Outputs from ITLUP can also be fed back into travel models in an iterative fashion to create an integrated model of the transportation/land-use interaction.

Data Required

Inputs to the model are ideally provided on the level of TAZs and include base year and historical data on employment, households, land consumption, and travel impedance as follows.

By Zone:

- Employment by type (1-digit level Standard Industrial Classification [SIC]) for base year and one previous period;
- Households by income quartiles for base year and one previous period;
- Total land area;
- Land area by use category (residential, industrial, commercial);
- Vacant developable land; and
- A zonal travel impedance matrix (travel time or cost from travel model).

For study area as a whole:

- Control totals for households and employment in 5-year intervals for forecast period.

Advantages

- Data requirements match data maintained in most jurisdictions,
- Compatible with outputs from standard travel models, and
- Long history of successful adaptations, substantial literature/knowledge base on application.

Disadvantages

- Involves high level of effort and substantial commitment of time and resources;
- Lacks representation of the land market clearing process (this will be a component of a model revision called METROPILUS, see below);
- Simplifies the relationship between employment and household generation and does not account for important household demographic characteristics shown to affect location choices such as household structure (number of children and workers) and ethnicity;
- Cannot address changes in policy alternatives such as land use regulations, economic development strategies, or major infrastructure improvement; and
- Initial runs of the model have been know to produce unreasonable forecasts requiring manual intervention with adjustment of calibration residuals and constraints. The lack of standardized procedures for these adjustments leave open the possibility for the introduction of error.

Pending Revision

Putman has announced that ITLUP is in the process of being replaced with a more comprehensive package called METROPILUS. Active users of ITLUP will be upgraded to the new package when it becomes available. METROPILUS will be based on the location surplus notion and will integrate employment location, residential location, and land consumption in a single package. The addition of land value (relative housing prices or a multivariate index) as an attractiveness measure is another planned feature. The model will interface with ARCVIEW GIS software (ESRI) for input, output, and some statistical routines (DVRPC, 1996).

Requirements for Implementation

Licensing: consulting contract packages range from $15,000 to $100,000 depending on scale of implementation.

Platform: mainframe, DOS, Windows, UNIX.

Staffing: teams vary in size and expertise depending on scale and consulting services usually one senior-level and one junior-level staffer.

Consulting for implementation and calibration available.

MEPLAN

The MEPLAN model developed and refined over the last 30 years by Marcial Echinique and others is also based on the Lowry-gravity model principle but includes components of economic theory, such as input-output modeling, discrete choice analysis, and random utility theory that are not part of the standard Lowry construction (see Figure 8-5).

The core function of the model is to determine land consumption in and among zones by linking supply and demand for space, transport, and factors of production such as labor. Employment markets are modeled using input-output techniques to determine industrial composition and interindustry flows. Employment in base industries, those industries dependent on exogenous export-driven demand, is determined. Basic employment drives demand for housing and non-base industries such as retail and services.

Random utility theory is employed in the allocation of industries and households to zones firms and households are assumed in this model to act in a utility-maximizing and cost-minimizing way. The model attempts to approximate market mechanisms by calculating elasticities in demand with the respect to the prices of land, floorspace, labor, and travel. In this way, the location choices of employers and households are based not only on the time-cost of travel (the effect of congestion on the network) as in other models, but the price of land.

The input-output methodology allows for demand for the transport of goods between zones to be modeled in addition to the work and non-work trips of household members. Person-trips and commodity flows between zones are distributed across modes and routes using iterative multipath assignment techniques common to transportation demand models.

MEPLAN consists of three submodels and an evaluation module. LUS is the regional/urban land use and economic model which estimates the demand for inputs to basic production in zones. FRED is an interface program that converts demand for production inputs at the zonal level to flows of goods and people. The TAS submodel distributes these flows across modes and routes in the network. The model is typically run in 5-year increments over a 20+-year study period to achieve a balance between the land use and transportation components. The effects of changes in prices and accessibility are lagged to approximate the real world constraint of imperfect information and the non-instantaneous nature of location change. The evaluation module, EVAL, allows for the assessment of the land use and transportation effects of a project through cost-benefit analysis of policy scenarios in comparison with a base case. The model's reliance on market mechanisms makes it particularly suitable for evaluating policy changes that result in changes in price or supply of production inputs. Examples include the effects of increases in parking charges, public transportation fares, and tolls.

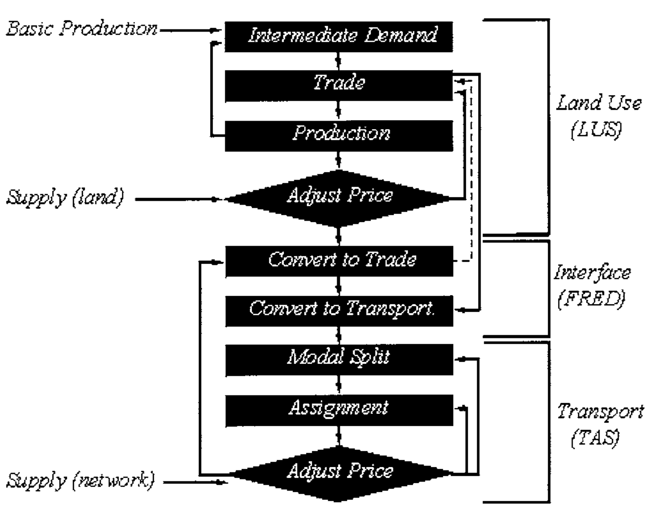


Figure 8-5. Structure of MEPLAN (source: Oryani & Harris, 1996).

<u>Data Required</u>

Inputs to the model are provided on a zonal level. It may be necessary for the zones to be aggregations of TAZs if the economic data are not available at the proper level of detail. Data required to run the model include the following:

- Land use and land prices (by sector),
- Floorspace and prices (by sector),
- Population (by household type),
- Employment (by sector),
- Input-Output tables (user-determined sector aggregation),
- Exogenous forecast of basic employment, and
- Transportation network (by mode).

Additional data by zone and economic sector are required for calibration:

- Exogenous production,
- Induced production,
- Unit production prices,
- Valued added to each unit of production,
- Exports and imports, and
- Restrictions to internal production.

<u>Advantages</u>

- Fully incorporates market functions and the pricing factors of production and transportation for a closer approximation to the theoretical understanding of real-world mechanisms;
- Allows for evaluation of a wide range of user-defined policy scenarios affecting supply, or pricing of transportation/ production factors; and
- MEPLAN allows for flexibility in the spatial level of analysis, making amenable to data constraints.

Disadvantages

- Substantial data requirements including detailed regional economic data not normally collected or manipulated by transportation planners.
- Calibration is a detailed process often requiring developer assistance. The calibration process may have limited utility because it is largely cross-sectional in nature.
- Model's reliance on input-output data makes it more suitable to intraregional studies rather than intraurban applications. It may be difficult to accurately disaggregate input-output data to the small TAZs seen in urban areas. Beyond the problem of disaggregation, if only a few industry sectors are represented in small urban TAZs, the functioning and accuracy of the model maybe compromised.
- No method for linking with commonly used travel demand models since MEPLAN contains its own travel demand component.

MEPLAN has been limited to one application in the United States: an academic exercise for the Sacramento, California region.

Requirements for Implementation

Licensing: approximately $40,000 for full package of modules.

Platform: DOS, Windows, and UNIX S.

Staffing: team consisting of a planner, transportation engineer, and economist.

Consulting for implementation and calibration available.

TRANUS

TRANUS and MEPLAN are based on the same theoretical framework differing little in basic structure or data requirements. TRANUS make greater use of logit-based formulations for mode and route choice.

TRANUS has also been applied to Sacramento in an academic project and is currently in use by the Oregon DOT.

Requirements for Implementation

Licensing: $6,000.

Platform: Windows 95.

Staffing: team consisting of a planner, transportation engineer, and economist.

Consulting for implementation and calibration available.

METROSIM

The METROSIM model is a discrete choice model of housing location developed by Alex Anas at the State University of New York at Buffalo. The model has been adapted for several specific regional applications: CATLAS for the Chicago area (residential location, housing, and mode choice); CPHMM, a prototype dynamic housing market model for Chicago, Houston, Pittsburgh, and San Diego MSAs; and a NYSIM, which modeled housing location, work and non-work travel, and commercial real estate markets for the New York Metro area MPO.

As with MEPLAN and TRANUS, METROSIM takes an economic market-based approach to residential and employment location. METROSIM is not, however, based on the Lowry gravity model formulation. The model is made up of several submodels estimating activity in basic industry, nonbasic industry, households, residential and commercial real estate, vacant land, travel demand, and traffic assignment. A simultaneous equation system is used achieve equilibrium in three market sectors: labor market and employment location, housing market, commercial space. The model iterates between the interactions of the three markets and the transportation network until an overall equilibrium state between land use patterns and transportation flows is achieved. The model can produce either one long-run steady state equilibrium forecast or an incremental set of forecasts on an annual basis. (See Figure 8-6.)

Calibration is cross-sectional, dependent on one base year, employing econometric techniques. The functioning of the model and the calibration is complex and requires the direct involvement of the developer.

Data Required

- Census Transportation Planning Package (CTPP, Urban Elements 1, 2, and 3);
- Transportation network (by mode); and
- Data on real estate parcel characteristics and values.

Advantages

- Minimal data requirements, data are available and familiar to transportation planners.
- Every aspect of the model is rigorously grounded in economic theory making one of the most theoretically consistent integrated models.

Disadvantages

- Complexity of model requires participation of developer.
- The model's assumption of equilibrium, perfect information, and the immediate adjustment of all households

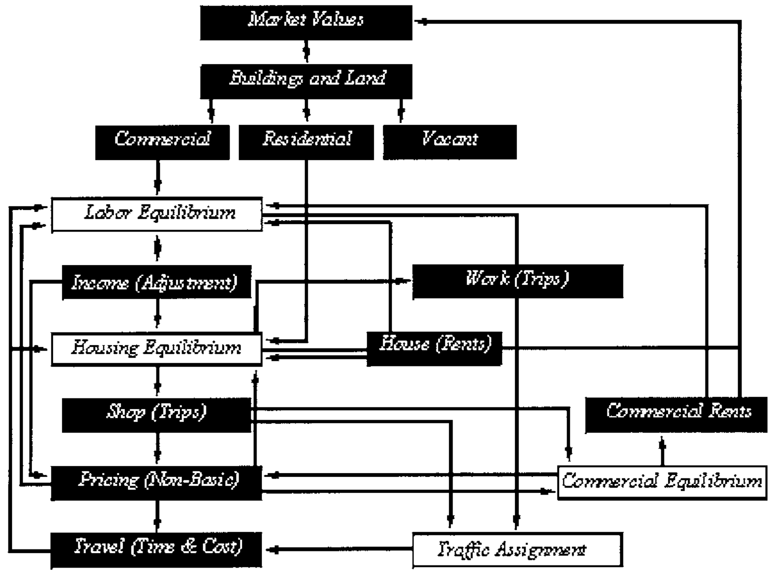


Figure 8-6. Structure of METROSIM (source: Oryani & Harris, 1996).

and businesses within each time period are not consistent with real-world conditions.

- The model is based on one-worker households. An adjustment for the multiworker households common today is possible but undermines the structure of the nested choice structure of the model.
- METROSIM is calibrated cross-sectionally with little history of long-term validation

<u>*Requirements for Implementation*</u>

Licensing: not distributed commercially, use by arrangement with developer.

Platform: UNIX workstation only.

Staffing: estimates should be obtained from developer.

UrbanSim

UrbanSim, one of the most recently developed integrated land use and transportation models, was created in the late 1990s by Paul Waddell and a team from the University of Washington under contract to Parsons Brinkerhoff (see Figure 8-7). The development of UrbanSim has been funded by the Oregon DOT and the NCHRP, with subsequent funding from the State of Utah Governor's Office.

UrbanSim contains two categories of decisionmakers and choices influencing urban development: endogenous and exogenous. The decisions made by households, workers, businesses, and developers are endogenously modeled. The decisions made by the public sector are treated as exogenous, and are input to the model in the form of policy scenarios. The design of treating urban development as an interaction between market behavior and governmental actions is intended to maximize the realism of the model as well as its utility for assessing the impacts of alternative governmental plans and policies related to land use and transportation.

The model endogenously predicts the location of businesses and households; the location, type, and quantity of new construction and redevelopment by developers; and prices of land and buildings. A household mobility and location submodel simulates the household decision to stay or move in a given year and predicts housing type and location if a move is undertaken.

Multinomial or nested logit estimation techniques are used to model household behavior in a manner similar to the modeling of mode choice in travel demand models. Price and accessibility are among the factors influencing locational choice. A business location submodel also uses logit functions to distribute business among zones in each year of the model run.

The simulation of development decisions to convert vacant or developed land to other uses is based on calculations of demand and development profitability carried out by a development submodel. Infrastructure availability and government constraints such as zoning, growth boundaries or impact fees can also be factored into the development decision-making process.

UrbanSim produces results based on adjustments in prices, land availability, and accessibility on a yearly basis for the entire study period. The model user defines time periods for recalculation of travel costs and congestion using a travel demand model (TRANPLAN, EMME/2, MINUTP) external to UrbanSim. The travel demand model can be run at regular

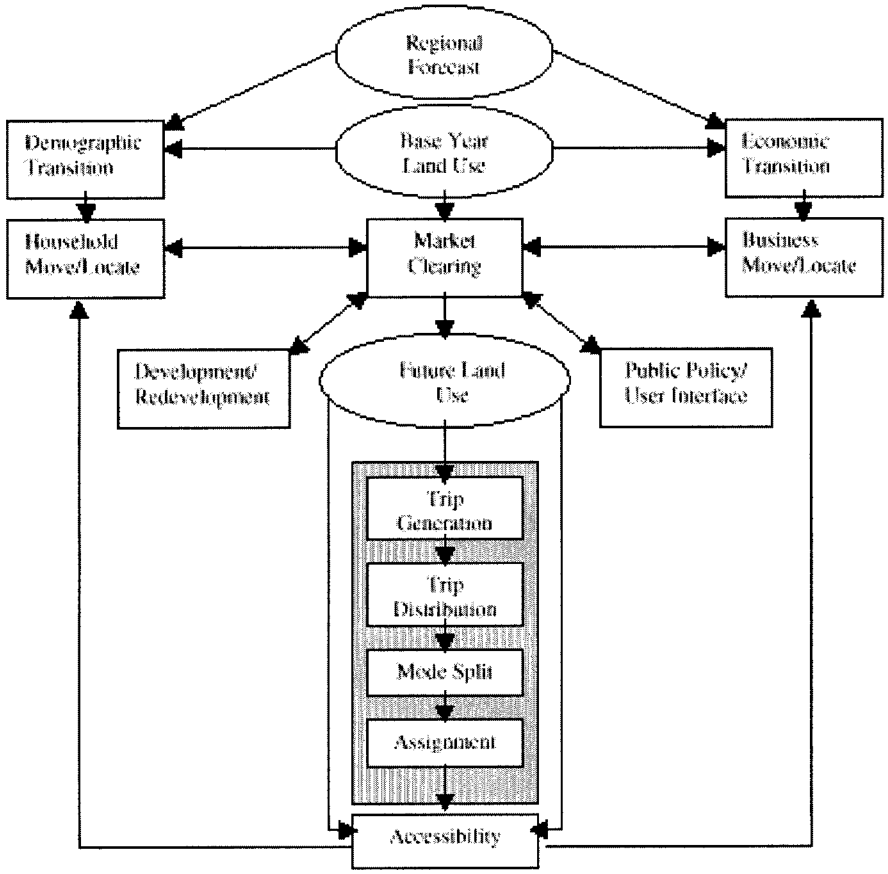


Figure 8-7. Structure of UrbanSim (source: Waddell, 1998).

intervals or to incorporate changes anticipated by the completion of major facilities or improvements.

Calibration is performed using historical time-series data in multiple regression analyses to estimate bid price functions for different household groups. Outside statistical software is used for regression (SAS, SPSS). Logit estimation using outside packages (Limdep, Alogit) is also necessary. Validation with known data for historical periods can also be conducted with model runs.

<u>Data Required</u>

- Regional control totals for population and employment,
- Household characteristics (Census STF3 and PUMS),
- Existing land use (at parcel level, usually GIS input),
- Land use plans (compatible with parcel-level GIS),
- Infrastructure plans (compatible with parcel-level GIS),
- Environmental constraints (compatible with parcel-level GIS),
- Regional development costs (by land use type),
- Government regulations (impact fees, tax abatements), and
- Travel cost matrix (from external travel demand model).

<u>Advantages</u>

- No licensing fee for use and designed for any microcomputer platform capable of running Java (Windows, MacOS, Unix).
- Provides results based on market mechanisms and policy constraints at a high level of spatial disaggregation (TAZ).
- Explicitly accounts for use of land, and characteristics of households and businesses in yearly time periods. Accounts for new development and redevelopment.
- Capable of modeling impacts of land use and other government policy scenarios.
- Compatible with existing travel demand models and transportation planning data.
- Data output to built-in GIS reader for mapped results.

<u>Disadvantages</u>

- Newly developed software does not have track record of practical applications, calibration, and validation.
- Substantial data requirements including parcel level data on land use, vacant land, environmental constraints, and infrastructure availability. Requires GIS expertise and

careful preparation of data of a level and type not normally utilized by transportation professionals.

Pending Revision

According to the UrbanSim web page, the model is being reworked to fix bugs and accommodate recent improvements. The new version was scheduled to be available for free download in Fall 2000. Previous versions are not available and the developer recommends against their use.

Requirements for Implementation

Licensing: no fee; free for download (www.urbansim.org).

Platform: DOS, Windows, MacOS and UNIX (requires free Java Developers Package).

Staffing: travel modeler, land use planner, GIS analysts.

Contact developer for information on consulting for implementation and calibration.

Other Operational Models

Several MPOs have developed in-house land use and transportation models to meet their forecasting needs. One example is the Projective Optimization Land Use Information System (POLIS) developed by Poulicos Prastacos for the Association of Bay Area Governments. POLIS is a mathematical programming formulation of the Lowry model. The model is based on random utility theory. Basic employment and travel impedance are exogenous to the model. It is similar in function, data requirements, and output to ITLUP.

There are a few examples of models that are not fully integrated transportation and land use models but contain components that may be useful those studying the indirect effects of transportation projects:

- **CUF** (California Urban Futures)—Developed by John Landis at the University of California at Berkeley, CUF operates entirely within the ArcInfo GIS platform. Although the model is a large scale metropolitan simulation model, it cannot be integrated with travel demand models and does not include travel cost considerations—it would not therefore be useful on its own for modeling transportation improvement alternatives. It does allow for modeling of land use policy alternatives and provides bottom-up population and household projections and residential land consumption predictions.
- **TELUS** (Transportation, Economic, and Land Use System)—Developed for the North Jersey Transportation Planning Authority (NJTPA) by a team from the New Jersey Institute of Technology and Rutgers University, TELUS is a transportation management software tool. The software combines a database of projects in the Transportation Improvement Plan (TIP) with the capability to translate the cost of improvement projects into economic impacts for the 13-county region covered by the MPO. TELUS is also designed to measure the change in property values related to transportation investment projects and changes in accessibility. Property value impacts are measured using a comparison between similar projects and communities, and a multiple regression model (covering the period 1990–2000) describing the relationship between the cost of improvements and changes in property values.
- **SCALDS** (Social Cost of Alternative Land Development Scenarios)—The SCALDS model was developed in 1998 by Parsons Brinkerhoff Quade & Douglas, Inc. for FHWA. The model is not a fully calibrated land use and transportation model. It is, however, a comprehensive accounting framework for evaluating many of the most important costs and benefits associated with transportation systems and related land development. The model would be useful in evaluating the impacts of a variety of land use and growth scenarios developed on the regional level. The model does not provide forecasts of induced growth or allocation of projected development to sub-regional zones. The model has three main calculation paths:
  1. *Physical Development*—This portion of the model estimates consumption of land; the projected mixture of new housing units; local infrastructure cost; the annual operating cost of sewers, water, and storm water; and the average amount of non-residential building space needed to support new development. A short term projection of school children and school costs is also provided. These outputs are based on growth forecasts generated by MPOs or other regional entities that are exogenous to the model. The growth forecasts include projections of population, households, housing units, vacancy rate, employment, and vehicle miles traveled (VMT), aggregated at the regional level.
  2. *Travel Cost*—This path models the annual operating cost of peak and non-peak travel on a passenger miles traveled (PMT) basis. Person trips are derived from household estimates and the average number of trips per household. Trips are allocated to modes based on the percentage of trips made by vehicle type and PMT is calculated from these figures. Costs per passenger mile are then estimated based on depreciation and financing, insurance, registration, fuel, maintenance, transit, parking, and value of travel time costs.
  3. *Air Pollution and Energy Consumption*—This portion of the model estimates air pollution by transport mode, and energy consumption by transportation and residential and non-residential land uses. The model uses

Model	Model Theory	Sectors Modeled	Policies Modeled	Data Required	Level of Aggregation	Platform	Implementation
ITLUP (DRAM/ EMPAL)	Lowry formulation random utility network equilibrium	employment population housing land use travel	land use regulations transportation improvements	employment by industry households by income quartile total land area land area by use category vacant developable land travel cost matrix	TAZs or higher level of aggregation	DOS Windows Unix	$15K -$100K complete consulting contract package 2-person plus planning team
MEPLAN	Lowry formulation random utility network equilibrium land use equilibrium	employment population housing land use travel networks workplaces goods transport	land use regulations transportation improvements transportation cost changes	land use and price by sector floor space and price by sector population (by household type) employment by sector input-output tables forecast of basic employment transportation network by mode	Groupings of TAZs	DOS Windows Unix	$40K complete licensing consulting for implementation/calibration available planner, engineer, economist team
TRANUS	Lowry formulation random utility network equilibrium land use equilibrium	employment population housing land use travel networks workplaces goods transport	land use regulations transportation improvements transportation cost changes	land use and price by sector floor space and price by sector population (by household type) employment by sector input-output tables forecast of basic employment transportation network by mode	Groupings of TAZs	Windows	$6K complete licensing consulting for implementation/calibration available planner, engineer, economist team
METROSIM	random utility general equilibrium	employment population housing land use travel networks workplaces	transportation improvements	Census Transportation Planning Package (CTTP) transportation network by mode data on real estate values	TAZs or higher level of aggregation	Unix	licensing by arrangement consulting for implementation/calibration required team size varies
UrbanSim	Lowry formulation random utility locational surplus land use equilibrium	employment population housing land use travel workplaces	land use regulations transportation improvements	regional control totals for population and employment households (STF3 and PUMS) parcel land use (GIS) land use regulations (GIS) infrastructure plans (GIS) environmental constraints (GIS) regional development costs government regulations travel cost matrix	TAZs or higher level of aggregation	DOS Windows MacOS Unix (Java Developers Kit)	no cost for downloadable software or documentation consulting not required for use team size varies, must include GIS expertise

Figure 8-8. Attributes of integrated land use and transportation models (adapted from: Wegener, 1994; NCHRP Report 423A; and Oryani and Harris, 1996).

accepted national estimates derived from recent literature. Locally developed estimates or inputs from other modeling estimates may be substituted.

Further information on the SCALDS model and a complete copy of the Microsoft Excel spreadsheet model is available through the FHWA website (http://www.fhwa.dot.gov/scalds/scalds.htm).

- **Smart Growth INDEX—**This GIS-based sketch planning tool was prepared by Criterion Planners in 1999 for the U.S. EPA. The model offers evaluation of alternative growth scenarios, land use plans, and urban design features for consistency with community goals and policies. Smart Growth INDEX employs a gravity model formulation to allocate exogenous regional population forecasts to sub-regional zones based on user-selected policy constraints and incentives. The model is designed to score the results of land use scenarios against a set of performance indicators. The model is also capable of scoring a micro-level land use plan or urban design with another set of environmental performance indicators. An abbreviated four-step travel demand sub-model is a component of the model but input from an external travel demand model such as TRANSCAD or MINUTP is also acceptable. Data required by the model in ESRI (ArcView) shapefile format include existing housing by type, road network (street centerlines by functional class), employment count and location, and current or proposed land-use plan designations. Features constraining urbanization such as steep slopes, flood plains, and urban growth boundaries can also be entered into the model in shapefile format.

  Outputs of the model include residential density and location, employment density and location, land use mix, jobs/ housing ratio, VMT, travel costs, and air/water quality, and resource use information. The model produces spatial output based on land use cells of a size specified by the user. Land prices are not modeled and it is not possible to change the parameters of the gravity model component.

  Smart Growth INDEX offers visual output and sketch-level analysis of the impacts of transportation improvements and land use policies, producing a sub-regional allocation. Model outputs can be used in support of other analysis techniques described in this module. More information on the model is available through the EPA website (http://www.epa.gov) or Criterion Planners (http://www.crit.com). The model requires ArcView or ArcInfo GIS (ESRI) for operation.

APPLICATION OF ANALYSIS TECHNIQUES

The analysis techniques described above are applicable to a wide variety of systems planning and project evaluation circumstances. The discussion in Module 3 on scoping reviewed the issues and considerations involved in selecting methods. After the range of potentially significant indirect effects have been identified (see discussion of Step 4 in Module 7), the general approach selected at the scoping stage should be reevaluated in light of new information and methods for analysis should be selected. This section provides examples of how the methods discussed in this module can be combined to produce a complete analysis of indirect effects. Examples are provided for analysis in the context of transportation systems planning and project evaluation under NEPA.

Transportation Systems Planning

Although the requirement for a separate formal Major Investment Study (MIS) was eliminated with enactment of TEA-21, the Act and subsequent regulations now proposed by FHWA and FTA recognize the importance of considering indirect and cumulative effects in the planning of transportation systems that takes place before the NEPA process. By considering the range of potential indirect and cumulative effects in the evaluation of mode and corridor alternatives, the sponsoring agency can better evaluate the broad range of alternatives and lay the ground work for indirect and cumulative effects analysis required by NEPA/SEPA in the evaluation of project alignment and design alternatives.

The assessment of indirect effects in the planning phase involves the following considerations:

- *Induced Growth*—Because details related to alignment and design are usually unknown in the planning phase, the focus of the assessment is on the potential for induced growth and related social and ecological effects. Where plans regarding access nodes (e.g., interchanges, stations) are known, consideration can be given to localized induced growth effects and encroachment-alteration effects on notable features.
- *Link Between Land Use Futures and Transportation*—In the planning of transportation systems, future demand for travel is an important consideration. This demand is related, in part, to anticipated growth in population or employment and land use decisions made by those groups. Although these variables are part of Travel Demand Modeling efforts used throughout many urbanized areas to evaluate plan alternatives, there must be specific feedback between transportation and land use systems to adequately evaluate indirect effects. Very often a land use scenario is used to determine travel demand but the impact of a transportation system on land use decisions is not explored. This feedback loop is at the heart of induced growth analysis. Feedback is achieved by developing qualitative or quantitative land use scenarios based on the change in accessibility attributable to each planned alternative. Cumulative effects are addressed by incorporating other actions into the transportation and land use scenarios.

- *Link Between Land Use Futures and the Environment*—The final step in a complete indirect and cumulative effects evaluation at the planning stage is the linking of land use forecasts to notable features in the physical and natural environment. This is most easily accomplished using a cartographic overlay technique or GIS. These methods would allow for graphical representation of potential areas of conflict between the transportation system, anticipated planned and induced development and notable features in the environment in both the planned corridor and surrounding area.
- *Revising and Updating Analyses*—Indirect and cumulative effects analyses conducted during the planning stage may serve as a good base for the analyses to be conducted in the evaluation of alignment and design impacts. Since significant periods of time often elapse from the evaluation of system plans to the environmental documentation for plan alternatives, however, care should be taken to re-evaluate assumptions in light of the time elapsed and greater knowledge of project details. Encroachment-alteration effects should also be explored as greater detail on project design is revealed. Sensitivity and risk analysis techniques (see Module 9) can be valuable tools in exploring the extent to which findings in a forecast change as assumptions change. Survey or expert panel techniques or a rerun of a forecast model could provide update to assumptions that may be required.

The methods described in this module can be combined in various ways to analyze indirect effects in the planning phase. Options in methodology include but are not limited to the following examples.

Example 1

- Use survey of experts, consultation with local planners, or local/county comprehensive plans to develop base forecast of population, employment, and land uses for groupings of TAZs or other sub-regional level of analysis.
- Use survey or panel consultation techniques to develop criteria for reallocation of population/employment/land uses to sub-regional areas in the vicinity of a transportation corridor to be improved. Reallocation should be considered for each plan alternative.
- Map base and action alternative forecasts along with key environmental features drawn from existing secondary sources to reveal areas of potential social or ecological impact.
- Using findings from mapping exercise, consultation techniques, and literature/comparative case review to write scenarios for base and alternative forecasts. Compare scenarios to each other and significance criteria to draw general conclusions about impacts.

Example 2

- Use a gravity model to allocate study area population and employment control totals to groupings of TAZs based on calculation of land available for development in each group and accessibility to other groups in the study area. Accessibility is calculated from zone-to-zone travel times produced by a Travel Demand Model (TDM) aggregated to the TAZ group level.
- Repeat the gravity model exercise for each plan alternative with new accessibility factors derived from runs of the TDM including the mode or corridor alternative.
- Map base and action alternative forecasts derived from gravity model runs along with key environmental features drawn from existing secondary sources to reveal areas of potential social or ecological impact.
- Using findings from mapping exercise, and supplementary consultation techniques, and literature/comparative case review to write scenarios for base and alternative forecasts. Compare scenarios to each other and significance criteria to draw general conclusions about impacts.

Example 3

- Employ an integrated Transportation-Land Use Model that uses TDM files for travel time input. The model will be run several times to examine each possible combination of transportation and policy alternatives. The model will be based on exogenously determined control totals and will be calibrated based on historical data and the professional judgement of agency analysts and local experts.
- Model output can be mapped using standard cartographic or GIS techniques along with key environmental features drawn from existing secondary sources to reveal areas of potential social or ecological impact.
- Using findings from mapping exercise, and supplementary consultation techniques, and literature/comparative case review to write scenarios for base and alternative forecasts. Compare scenarios to each other and significance criteria to draw general conclusions about impacts.

Project Evaluation

The methods employed in the analysis of project alternatives for NEPA are similar to those employed in the planning phase. Since project characteristics and circumstances are more refined however, the techniques, particularly the quantitative methods can be employed at a greater level of detail. Examples of how techniques can be combined to conduct analyses are given below for two possible scenarios—a scenario requiring basic techniques and one requiring a more detailed analysis. Tools should be tailored for the particular project circumstances, level of information, and resources available.

Example 1—Basic Analysis Techniques

The addition of an interchange to a limited access highway in a low-growth rural location is expected to have minimal potential for induced growth. To assess the induced growth potential and predict its magnitude the analyst would

- Use simple trend extrapolation techniques to produce baseline study area projections of population and employment for the 20-year assessment period. (This was necessary because the county planning office had not conducted forecasts for the area.) Analyst writes uses data to develop a "No Action Scenario" describing future conditions without the improvement.
- Cite literature showing that interchanges in rural areas far removed from the urban core or employment centers are likely to induce only limited highway oriented development like service stations and convenience stores in quadrants nearest to oncoming traffic.
- Cite the limited nature of development following a similar project in an adjacent county 10 years ago.
- Write a scenario describing potential impacts from the conversion of a vacant parcel and several acres of nearby farmland to use by two gas stations, a convenience store, and a restaurant attracted to serve traffic using the new interchange. Analyst concludes that this scenario describes the lower boundary of reasonably forseeable induced growth.
- Write a scenario describing impacts arising from the construction of a large truck stop, a hotel, and several fast food restaurants. This scenario details the highest magnitude of growth that is reasonably foreseeable given assumptions established by the analyst.

Example 2—Detailed Analysis Techniques

A beltway in a high-growth rural and suburban fringe location is anticipated to create opportunities for commercial and residential development involving the conversion of agricultural and forest land. To gauge the impact that the new facility will have on the pace and location of development in the study area the analyst would

- Develop a general No-Action Scenario for the study area based on 20-year growth projections furnished by the local MPO.
- Use a gravity model to allocate study area population and employment control totals to TAZs based on calculation of land available for development in each zone and accessibility to other zones. Accessibility is calculated from zone-to-zone travel times produced by a TDM used previously by the MPO. At the end of the process, the No-Action Scenario is refined to describe future development on the TAZ level.
- Repeat the gravity model analysis for every project alternative based on changes in zone-to-zone travel time produced by a TDM analysis of project alternatives conducted by the MPO previously to evaluate project feasibility.
- Calculate land consumed in each TAZ by population and employment growth and map the findings on the GIS maps created to show existing conditions. This analysis reveals potential areas of conflict with the natural environment (induced-growth related impacts) and current land use regulations.
- Compare gravity model findings with surveys of local real estate development and land use professionals and other stakeholders.
- Develop a scenario for project alternatives based on findings from quantitative and qualitative analyses.

RESOURCES AND SUPPLEMENTARY READINGS

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COURSE MODULE **9**

STEP 7—EVALUATE ANALYSIS RESULTS

OVERVIEW

Assessing the magnitude of indirect effects, the goal of the previous step, involved making several types of assumptions regarding the nature of the impact-causing activities, the nature of the cause-effect relationships, and how the environment will be affected by the impacts.

The objective of this step is to evaluate these assumptions and the uncertainty they produced so as to better understand the indirect effects. The product of this step should be thorough documentation of any uncertainty and how that uncertainty may influence the range of indirect and cumulative effects.

This module will

- Describe the issues involved in evaluating analysis results,
- Outline a basic technique for analysis evaluation,
- Provide criteria to be used in assessing the need for more detailed evaluation techniques,
- Discuss more detailed evaluation techniques, including
  – sensitivity analysis, and
  – risk assessment.

CONSIDERATIONS

The purpose of the framework to this point has been to outline techniques and procedures for identifying and estimating indirect effects of proposed transportation projects. The goal of these tasks has been to produce an assessment suitable for informing the decision-making process and the evaluation of alternatives. There is inherent uncertainty in estimating indirect effects, however, and a risk that the actual outcome will differ from that forecasted. Information regarding the level of uncertainty in an estimate of indirect effects should, therefore, be communicated to decisionmakers and the public for consideration along with the results of the analysis. Similarly, information regarding differences of opinion among stakeholders and experts consulted with respect to forecasted outcomes should also be disclosed. Included in this disclosure should be discussion of differences on goals, notable features, indirect effects meriting analysis, and analysis techniques and results. The basic and detailed methods involved in undertaking this evaluation are discussed below.

BASIC TECHNIQUE FOR ANALYSIS EVALUATION

In circumstances where either substantial indirect effects have been found or where no indirect effects have been found, it may not necessary to apply some of the more detailed sensitivity or risk analysis techniques described below, even if detailed techniques have been used in other steps in the framework. The key criteria in assessing the need for detailed evaluation are (1) whether the analysts or stakeholders believe that there is any level of uncertainty regarding the underlying assumptions used to estimate the indirect and cumulative effects, and (2) whether changes in the underlying assumptions can be expected to result in significant changes in the findings.

If uncertainty in the underlying assumptions is recognized but variation in the assumptions is unlikely to significantly alter the findings, then the uncertainty and conclusions regarding sensitivity should be carefully documented and the analyst may proceed to the final step in the framework.

If analysts or stakeholders see a level of uncertainty in the assumptions employed and that uncertainty is likely to significantly alter the findings, then a more detailed evaluation is warranted.

DETAILED TECHNIQUES FOR ANALYSIS EVALUATION

There are two key techniques that are of use in evaluating indirect effects analyses:

1. *Sensitivity Analysis*—This procedure involves changing forecast assumptions one at a time to test the sensitivity of effects to the particular assumptions. In other words, the purpose of this analysis is to test whether slight shifts in the analytical assumptions would cause larger changes in the effect, and help clarify degrees of confidence in estimating effects. This technique is applicable to both qualitative and quantitative assessments. Where multiple scenarios for the same project or no action alternative have been developed (i.e., best and worst-case), sensitivity of impacts to changes in assumptions is known and this step need not be repeated.

   There are several disadvantages to this method of evaluation (Lewis, 1995):

– Assumptions and judgements are often varied by arbitrary amounts instead of by reference to reasoned analysis of potential error. To avoid this, an attempt should be made to construct reasonable alternative scenarios.
– The what-if assumptions or scenarios used in sensitivity analysis do not identify the probability of alternative outcomes. This is overcome by using risk assessment techniques (see below).
– Worst-case scenarios often assume the highly unlikely event that all assumptions will deviate from expectations in the same direction, providing less information to the analyst than a more probable scenario.

2. *Risk Analysis*—This method includes a family of forecasting techniques and planning processes used to examine risk and uncertainty in alternative courses of action. It is best performed when quantitative methods have been used. Risk analysis seeks to improve the quality of information available for decisionmaking by revealing and clarifying the implications of uncertainty in technical and analytical decision-support material. There is no presumption of best or most accurate forecast; rather, the whole range of conceivable outcomes is arrayed together with the estimated probability of each occurring. Combined with group-oriented public involvement methods (e.g., a collaborative task force of stakeholders) risk analysis can promote consensus. In this way, it can bridge gaps between the forecasting level and the policy level.

   Risk Analysis involves the following steps:

   – *Identify variables and causal factors*—this step has been performed in the identification and analysis of indirect effects.
   – *Elicit expert/stakeholder opinion on the uncertainty of variable and causal factors*—variables should be restated in ranges to reflect uncertainty, these ranges correspond to probability distributions. This step is best completed with the assistance of spreadsheet-based risk analysis software.
   – *Report results*—risk analysis software will take a quantitative model and find the most likely outcome based on the probability distributions of the variables. Each output variable will be stated as a probability distribution indicating the range in which it could be expected to vary and the probabilities of those alternative outcomes.

Once the level of uncertainty in assumptions and outcomes has been properly explored and documented, the analyst may move on to assessing consequences of indirect and cumulative effects and discussing options for mitigation.

RESOURCES AND SUPPLEMENTARY READINGS

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COURSE MODULE **10**

STEP 8—ASSESS THE CONSEQUENCES AND DEVELOP APPROPRIATE MITIGATION AND ENHANCEMENT STRATEGIES

OVERVIEW

The purpose of estimating indirect effects of proposed transportation projects is to contribute to the body of information that will support a decision about whether to proceed with the plan or project, as proposed; to formulate a revised plan or project; or to otherwise mitigate adverse indirect effects associated with the proposed plan or project. The objective of this step is to assess the consequences of the analyzed indirect effects and develop strategies to address unacceptable indirect effects.

This module will:

- Outline the considerations involved in assessing consequences, determining the need for mitigation, and developing a mitigation plan;
- Provide an illustration of the mitigation decision-making process; and
- Identify indirect effects mitigation techniques that can be used by the sponsoring agency or recommended to outside agencies, as appropriate.

CONSIDERATIONS

When assessing the consequences of an indirect effects analysis and the need for mitigation or enhancement measures, there are several major considerations:

- Does the analysis of effects provide a reasonable basis for informed decisionmaking?
- Are there significant effects that are seen as unacceptable?
- Are there practicable mitigation/enhancement measures?
- Are mitigation/enhancement measures within the jurisdiction of the sponsoring agency?
- What is the sponsoring agency's role when mitigation/enhancement measures are not within its jurisdiction?

These considerations are discussed in detail below.

Providing the Basis for Informed Decisionmaking

Uncertainty can lead to controversy regarding indirect effects. The project sponsor is responsible for the recommendation to the decisionmaker on the impacts and, therefore, bears the obligation to ensure that the descriptions and analysis in the indirect effects analysis are reasonable and accurate. One of the tests for reasonableness deals with the resolution of controversy. Should the question (e.g., degree of impact, likelihood of impact) have two sides, each with reasonable arguments, then the agency obligation is to reveal both sides of the matter and, using the agency expertise (or outside agency), choose between the sides. The key is to disclose the controversy and to make a reasonable choice on the impacts.

The review of case law discussed in Module 2 indicates a requirement that mitigation of effects (direct, indirect, and cumulative) be discussed in an EIS in sufficient detail to ensure that environmental effects have been fairly evaluated (see *Robertson v. Methow Valley Citizens Council*, 490 U.S., 109 S.Ct. (1983)). It is suggested that mitigation be considered for those indirect effects that are unacceptable. It should be noted however that what is acceptable to some may not be acceptable to others.

Determining When a Potential Impact May Be Considered Unacceptable

Guidance for determining what is unacceptable can be found in the initial steps of the indirect effects assessment process, i.e., the goals and notable features identification (see Step 2, Module 4). If the analysis indicates that the proposed project could produce effects that would conflict, delay, or interfere with a study area goal identified in Step 2, then the proposed project, or the activity of the project responsible for that effect, is potentially unacceptable. Step 2 also suggests that the goals identification process attach relative importance to each relevant goal. Effects that would conflict, delay or interfere with relatively important goals should be considered significant in the local context.

Relative importance is also helpful for dealing with uncertainty. Experience indicates that if something of extreme importance could be affected through a chain of causality linked to a proposed project, then there will likely be reaction to the effect regardless of the degree of uncertainty about whether the effect will really occur. As one commentator notes, "Whether a specific use of the land in reality causes any economic or social problems may not be as important as what people perceive the problem to be" (Loundsbury, 1981). The message for indirect effects assessment is that the goals identification should not be treated lightly, as it lays the foundation and context for the entire assessment.

Mitigation for Impacts to Notable Features

Depending on the project circumstances, mitigation of indirect effects on notable features may also require consideration. It is suggested that such consideration occur when one or more of the following circumstances exist:

- The indirect effect could worsen the condition of a notable feature considered sensitive or vulnerable.
- The indirect effect could interfere with or delay the planned or required improvement of a notable feature.
- The indirect effect could eliminate a notable feature that is valued or unique, or render the valued or unique feature ordinary.
- The indirect effect is otherwise inconsistent with an applicable law.

Determining the Practicability of Mitigation

As with mitigation of direct effects, mitigation of indirect effects is not always practicable. The U.S. EPA's Section 404(b)(1) Guidelines (40 CFR 230) provide a definition of the term "practicable" with respect to project alternatives as available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes. These considerations should be part of the evaluation of alternatives to avoid or minimize an indirect effect, or other form of mitigation.

Responsibility for Mitigation and the Role of the Sponsoring Agency

The issue of responsibility for mitigation was a common theme of interviews conducted as part of the research for this study. The essence of the issue is whether the indirect effect is within or outside the control of the sponsoring agency. This issue was a subject of debate in the U.S. EPA's promulgation of its "General Conformity Rules" (FR 63214-63259). These rules require that federal agencies make determinations that each of their agency's federal actions conforms to the state implementation plan for attaining and maintaining air quality standards. In developing the rules, many federal agencies stated that it is unreasonable to withhold a conformity determination where it is impracticable for the federal agency to remedy the situation. The U.S. EPA concluded that it would be unreasonable to interpret the Clean Air Act as requiring federal agencies to take responsibility for emissions that they can not practicably control and for which they have no continuing program responsibility.

The U.S. EPA used the Supreme Court's analysis in its 1989 decision in *Robertson v. Methow Valley Citizens Council* (409 U.S., 109 S.Ct. (1989)) to support this conclusion (see Module 2). In that case, which involved the Forest Service's issuance of a special-use permit to a private developer, the imposition of the mitigation plan was within the jurisdiction of state and local agencies not the sponsoring agency. The court held that: "it would be incongruous to conclude that the Forest Service has no power to act [on issuing the permit] until the local agencies have reached a final conclusion on what mitigation measures they consider necessary."

However, the court added that the federal agency in such circumstances does need to advise the state and local agencies with mitigation authority as to what it considered appropriate mitigation. This advice is considered part of the federal agency's NEPA responsibility.

It is suggested that mitigation responsibility for indirect effects of proposed transportation projects be based on the distinction between indirect effects that are within the control of the project agency and those that are outside the control of that agency, to the extent that such distinction is consistent with federal and state laws. The typology for distinguishing indirect effects outlined in Module 7 is consistent with this approach. Specifically, "encroachment-alteration" effects can be equated to "within the control" of the project agency, while "induced growth and effects related to induced growth" are generally "outside the control" of the project agency (the exception being to avoid or minimize impacts through change in access location, where practicable). Indeed, the U.S. EPA used airport expansion and adjacent development of an industrial park as an illustrative example of federal control within the preamble to its "General Conformity" rule. In the example, development of the industrial park is known to depend on FAA approval of the airport expansion. Under Step 5 of the typology, the airport expansion is a project that "would likely stimulate land development having complementary functions." For purposes of Clean Air Act conformity, the example notes that the FAA is responsible for emissions from airport-related activities but is not responsible for emissions from the industrial park. Within the context of the indirect assessment framework, however, the FAA would be responsible for analyzing the industrial park and its effects and recommending mitigation if such effects would be unacceptable.

Among those indirect effects that should be considered within the control of the project agency include the following:

- Generally, those indirect effects associated with the location of the project and its access provisions;
- Effects related to how the project is constructed (e.g., modification of regime, land transformation and construction, land alteration, resource extraction, etc.); and
- Effects related to how the project right-of-way will be used and maintained (e.g., traffic and traffic-related

effects, fertilization, chemical deicing, weed control, pest control, etc.).

METHODS

The primary method for assessing consequences and developing mitigation consists of a set of steps where each identified indirect effect is evaluated in the context of the overall aim of the project and study area goals and notable features. This process and the steps of the indirect effects assessment framework leading up to it are illustrated in Figure 10-1.

An effect that would adversely impact a study area goal or notable feature may require mitigation. If a mitigation effort is impractical, the sponsoring agency should fully document the reasons for the impracticability of mitigation and why the need for the project or plan and its benefits outweigh the unmitigatable impact.

If practical mitigation alternatives do exist, the sponsoring agency should determine whether such efforts are within its control or jurisdiction. For example, many mitigation efforts relevant to induced growth and its consequences are within the control of municipal and county agencies, not a sponsoring agency. In these cases, it is the responsibility of the sponsoring agency to identify and assess potential effects, recommend strategies for mitigation, and re-evaluate the extent of the effect if such mitigation efforts were implemented.

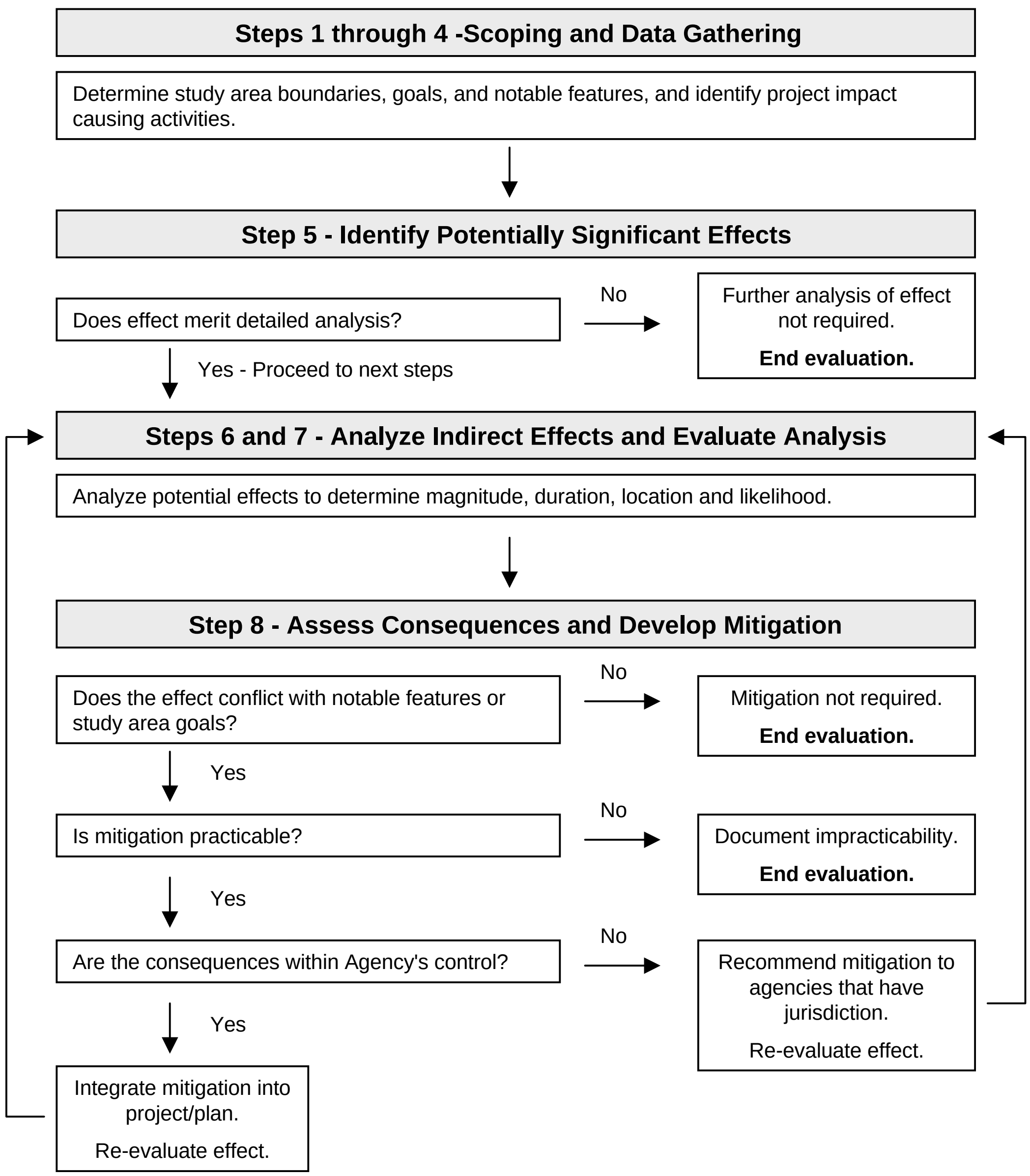

Figure 10-1. Indirect effects evaluation framework and process for assessing effect consequences and developing mitigation/enhancement strategies.

If mitigation strategies are within the jurisdiction of the sponsoring agency, the sponsoring agency should document its mitigation plan and how such mitigation efforts are expected to ameliorate adverse indirect effects.

Potential mitigation techniques relevant to the major categories of indirect effects and example applications of those techniques are outlined below.

Mitigation Techniques for Encroachment-Alteration Effects

Encroachment-alteration indirect effects, although often distant in time and space from the project, are similar to many direct project effects and can be addressed with similar mitigation strategies. As with direct effects, in many cases these strategies involve altering one of the following aspects of the project or plan within the control of the sponsoring agency:

- Facility type,
- Facility alignment,
- Facility design features,
- Techniques used during construction, and
- Facility maintenance.

Mitigation Techniques for Induced Growth and Related Effects

The three broad types of project-influenced development effects can be mitigated to some extent through a variety of access control or land use control techniques. These techniques are described below as they relate to the primary types of induced growth. It should be noted that not all regulatory techniques are available for use in all jurisdictions due to the structure of local land use laws and state enabling statutes.

Access Controls—The extent and location of complementary development and regional development shifts can be controlled to some extent through modifications to the access plan for the facility. For highway facilities, aspects of the project that can be modified include the location of interchanges, the type of the interchange (partial, one-way access or full access), connectivity to local arterials, traffic patterns on connecting roadways, the presence of frontage roads, and curb-cut regulations on connecting roadways. For transit facilities the location of stations, and the type of service, and frequency of stops can be modified. Some of these features such as the type and location of interchanges are within the jurisdiction of the sponsoring agency. Other issues, such as traffic patterns and curb-cut regulations may be within the jurisdiction of local agencies.

Context Sensitive Design—Many transportation agencies have begun to implement changes in their design standards that would allow for flexibility in design to meet the context of the local built environment and other local goals. This flexibility could help address the direct and indirect effects of transportation improvements. Examples of context sensitive design and flexible standards include, deviation from the standard length of a deceleration lane to protect a notable feature, modifying the design of an arterial that passes through a downtown area to allow for a boulevard that would better fit with the local context, and inclusion of special materials or design features to allow the facility to fit the scale and style of its surroundings. A major goal of context-sensitive design is to allow for local public input early in the design process so that costly delays and revisions can be avoided.

Zoning/Comprehensive Planning—Local zoning controls and comprehensive planning are usually outside the jurisdiction of the sponsoring agency but are often the most effective tools at controlling induced growth. Zoning involves the regulation of both the density and use to which land may be put. When combined with comprehensive planning, zoning allows communities to shape patterns of growth and development within their boundaries. To use zoning and planning effectively as a tool to mitigate project-influenced development effects, the land-planning process should ideally run concurrent with the transportation-planning process. If the land-planning process occurs at a later time, particularly in areas that are clearly in the path of future development, anticipation of the project among developers and land holders may make the planning process more difficult. A zoning response to a transportation plan or project is also most effective when it involves an areawide or regionwide approach to distinguishing areas suitable for growth from those requiring conservation. In circumstances where numerous planning jurisdictions are present in the impact area, the involvement of the sponsoring agency or another regional planning agency may be necessary to produce a coordinated response. Zoning regulations enacted as a response to the influenced development effects of transportation facilities should balance other needs of the community including employment and housing for all income groups.

Transfer of Development Rights (TDR)—Many communities are reluctant to pursue major changes in zoning regulations that may have the effect of decreasing the potential value of a property holder’s land. Under certain circumstances, a more restrictive change in zoning can be interpreted by the courts as a government “taking” of private property without compensation. A technique that works to eliminate the problem of wipeouts and windfalls inherent in the government regulation of land is TDR. This regulatory scheme allows property owners in areas where development has been restricted (sending district) to sell a portion of the unusable development potential of their land (e.g., a measure of density or bulk such as units per acres or floor area ratio) to properties in areas where the government would like to encourage more intensive development (receiving district). TDR often requires the ongoing involvement of the government to support a TDR bank to facilitate market transactions. It also involves extensive planning to evaluate the need for downzoning in sending and receiving zones to ensure an equilibrium in the market for development rights. Although its use is not widespread, TDR has been used successfully for many years in urban areas (New York City) and rural/fringe areas (Montgomery County, Maryland).

Growth Management Regulation—Several jurisdictions have pursued regulatory strategies that allow for regulation of the timing and location of residential and commercial development in a manner not addressed by traditional zoning regulations. Examples of growth management techniques include the following.

– Adequate Public Facilities Ordinances (APFOs)—This type of growth management strategy links approval for certain types of projects (those requiring subdivisions or variances, for example) to a review of the capacity of infrastructure to serve those projects. Infrastructure types often considered in these ordinances include water/sewer service, local transportation facilities, and other government services. Long range plans for the programming of infrastructure projects in Capital Improvement Plans are prepared as part of the ordinance and projects exceeding the capacity of infrastructure before improvements will be in place do not receive approval.
– Development Moratoria—Similar to APFOs, moratoria give local jurisdictions the authority to halt new development projects until public facilities are improved to an appropriate level. Moratoria have also been used to preserve corridors slated for transportation improvements.
– Urban Growth Boundaries—Some regions have adopted growth boundaries surrounding metropolitan areas to preserve open space around cities, slow the growth of suburban sprawl, and focus development into urban cores where infrastructure levels provide capacity for growth. These growth boundaries are often designed to accommodate growth projected for 20- to 30-year periods. Growth boundaries are effectuated by strictly regulating densities outside the growth boundaries or limiting the provision of infrastructure beyond the boundary. Regional authorities are often given the responsibility of regulating and planning the growth boundary system. Portland, Oregon's experience shows that growth boundaries can be successful in preserving green space and promoting development of the core, but regulations need to be reviewed frequently to prevent spillover growth just outside protected areas.
– Extraterritorial Zoning/Annexation—In some fast growing metropolitan regions, cities are given special authority over zoning issues and development applications in unincorporated areas outside city limits. This authority is meant to promote the orderly growth of the metropolitan area and compatibility between the city center and the periphery. Extraterritorial zoning authority is also granted with the expectation that city boundaries will eventually expand to keep pace with urban development. Policies meant to ease the process of annexation of incorporated or unincorporated suburban or fringe lands into a city's jurisdiction can mitigate against the induced growth impacts of transportation improvements by allowing planning, zoning, and growth management strategies to be implemented on a regional basis.

Resource Management and Preservation Regulations—Specific regulations designed to protect vital resources can work to guide the path and intensity of development and limit impacts on notable features related to induced growth. Examples of resource regulations include the following:

– Coastal zone management areas where development areas are delineated and development is permitted only under special circumstances in critical areas.
– Watershed management areas where development is regulated to protect the quality and quantity of water resources, prevent flooding, and promote water-related tourism and recreation.
– Agricultural districts where incentives such as lower property tax assessment levels, and shielding from neighbor nuisance complaints are combined with low-density zoning and use regulation to promote the continuation of agricultural uses.
– Special architectural districts where development is permitted as long as strict standards designed to preserve existing aesthetic and cultural resources are followed.

Land Acquisition/Conservation Easements—A technique for preservation of green space, habitat, or other important resource areas that is seeing increasing use is the acquisition of land or development rights by government agencies, non-profit groups, or other private initiatives. These groups purchase or accept donations of land and pledge to keep the land permanently undeveloped. Development rights can also be purchased while the underlying title and use is retained by a landholder through the use of conservation easements. These easements once written into a deed can permanently prevent development on a parcel regardless of future ownership. Carefully planned acquisitions can work to focus growth and protect notable features from growth related impacts.

Incentives for Brownfield/Infill Development—Tax abatements, low-interest loans, density bonuses, and relaxation of site cleanup requirements are all strategies employed by cities with capacity for development on former industrial sites (brownfields) or other infill locations. These strategies, especially when coupled with other growth management techniques, can make innercity parcels, with substantial access to existing infrastructure and services, more competitive with greenfield sites in the vicinity of transportation improvements, thus reducing the likelihood of growth in outlying areas.

Development Fees and Exactions—An increasing number of jurisdictions have enacted ordinances that provide for the assessment of fees on development projects that would require new infrastructure investments. These fees are all or part of the burden of new infrastructure costs onto the developer. While these fees may not dampen development in high-growth areas, these fees make the true costs of development more apparent to developers and prospective buyer and make areas already served by infrastructure more attractive than areas more distant from the core.

All of the techniques described above can be employed and combined to mitigate the likelihood of complementary induced growth and regional development shifts, and other effects related to land development attributable to transportation improvements. Although not all tools are available in all jurisdictions, sound comprehensive planning to prepare for land development impacts should be a component of all mitigation plans.

Techniques for the Systems-Planning Stage

Many of the techniques outlined above are applicable to the transportation-planning stage as well as the project development process. As noted above, comprehensive planning, resource preservation regulations, and other techniques meant to shape growth, when integrated with the planning of transportation systems will minimize the likelihood of indirect effects on notable features and conflicts with community goals. There are some additional techniques applicable to the systems-planning stage that may be useful, however.

Comprehensive Performance Measures—Traditionally in the planning of transportation systems, the assessment of need for a transportation project has been based in part on measures of mobility in the existing transportation system. These measures focus on the efficient movement of vehicles. This is often measured in level of service (LOS) ratings describing various states of traffic conditions. Mobility measures provide no linkage, however, with land use conditions in the vicinity of projects. This disconnect can lead to the potential for conflict with notable features or goals later in the process. Evaluating projects with performance measures related to accessibility will help better connect transportation needs, land use considerations, and concerns regarding sustainability. Such measures include the following:

– Vehicle miles traveled (VMT) or vehicle hours traveled (VHT),
– Accessibility to jobs and commercial centers, and
– impact on jobs/housing balance.

The use of integrated transportation and land use models that employ a feedback loop between transportation and land use choices will also help integrate evaluation of induced growth concerns into the systems-planning process.

Promoting Regional Coordination—As discussed throughout this handbook, early coordination on a regional level is the best method for evaluation and mitigation of indirect effects. Regional coordination is especially important in controlling induced growth because a variety of uncoordinated local regulatory responses may work to intensify effects in the least regulated areas.

WORK PRODUCT OF STEP 8

The product of assessing the consequences and developing mitigation should consist of documentation: the comparison of indirect effects to the relevant goals and notable features (the determination of consequences); the mitigation strategy developed to address any unacceptable indirect effect; or mitigation considered and reasons why mitigation is not practicable. The documentation should note what the mitigation entails, its anticipated effectiveness, how it should be implemented, and who is responsible for implementation. It should also be shared with those having a stakeholder interest in the studied effect and mitigation, as well as those responsible for ultimately implementing the mitigation, if responsibility lies outside the sponsoring agency. Completion of this last step in the indirect effects assessment process will allow for full documentation of the process in a transportation plan or project environmental documentation.

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Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation