Integrated Environmental Planning
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CHAPTER 10

The Impact of Change

A central assertion throughout this text has been that environmental planning is a proactive and future-oriented discipline where environmental information is blended with traditional planning concerns in order to arrive at a sustainable balance between human need and environmental quality. In this text we have also set out to demonstrate that environmental planning is a form or decision-making where a choice must be made among alternatives in relation to a set of goals and objectives that detail a desired future. Because of our emphasis on the future, given the recognized fact that this future is largely unknowable, embarking on the appropriate course of action is shrouded in an envelope of uncertainty. Although uncertainty cannot be eliminated, it can be understood and reduced. In this concluding chapter we will explore a family of procedures designed to assess change in the land-use/environment system, and explore avenues whereby environmental concerns can be better incorporated into the public-policy making arena. Our exploration begins with the environmental impact assessment process.

Environmental impact assessment

Environmental impact assessment has been characterized as the process of identifying and evaluating the consequences of human actions on the environment, and developing procedures for mitigating those consequences that are adverse (Erickson, 1994; Marriot, 1997; Canter, 1996). From its inception, environmental impact assessment (EIA) has been guided by one overriding goal: to incorporate into the decision-making process the consequences of human activities that were not being addressed adequately by the free-market exchange system (Lein, 1989). While the details of the EIA process, the technical guidelines, administrative procedures, and legal responsibilities that pertain to it vary from nation to nation, and within nations, a consensus is building regarding the fundamental elements that constitute EIA (Erickson, 1994). First in importance is the fact that EIA requires seeing the environment as the aggregate of things and conditions that surround every living and nonliving thing. Within the context of EIA the environment is not simply those nonhuman things and processes, but also includes the human world and the elements, processes, and conditions that pertain to people. Secondly, EIA is a decision-making tool whereby the possible and probable consequences of a human action are carefully examined before an irreversible commitment is made that will contribute to an adverse environmental change. Thirdly, EIA directs analysis on both the quantifiable and qualitative aspects of the environment. Here inclusion of the non-measurable qualities is critical. Conducting an assessment of impact to consider only those characteristics of the environment that are quantifiable omits critical factors that may influence decision-making and presents an incomplete view of the environment. Finally, EIA places emphasis on the concept of mitigation and asks for the detailed investigation of methods and alternatives that will reduce undesirable effects and enhance those effects that are beneficial.

Historically, when projects or policies were designed, little direct consideration was given to their possible environmental effects. Generally, environmental considerations entered into the decision-making process well after a project was underway, if at all. Decision-makers typically assumed a reactive posture when the environment was factored into their plans. However, as the cost of environmental damage became more evident it became incumbent upon society to examine its actions and attune them so they would assure the long-term viability of Earth as a human habitat. This responsibility has been embodied in, for example, the US National Environmental Policy Act and its numerous state and international successors. When the National Environmental Policy Act (NEPA) was signed into law on January 1, 1970, a significant step was taken in the US to change government decision-making and place the environment directly into the decision-making process. Following the enactment of NEPA, the concept of environmental impact was no longer a subject for academic discourse, but a physical reality that became government's responsibility to identify, manage, and control.

By definition, an environmental impact explains any alteration of environmental conditions or the creation of a new set of environmental conditions adverse or beneficial, caused or induced by an "action" or set of actions. Two terms in this definition are worth closer examination. First, consider the term "alteration". If we go to the dictionary, the term implies the act of making something different. It does not suggest how, where, or why, nor does it place a value judgment on whether the difference is good or bad. The term is purposely nonspecific and suggests that decision-makers look seriously at the nature of their proposals and explore conditions in their broadest context. Similarly, the use of the term "action" is also necessarily vague. An action can include a range of governmental activities such as the allocation of money, the installation of a program, the implementation of a policy, the granting of a permit, the creation of a new physical structure or plan, or the modification of an existing plan or design.

The impacts produced by these actions can be either primary or secondary. This distinction is important because it recognizes the interconnectedness of the environment and the flow of process (impact) through a system (environment). Primary impacts define alterations of environmental conditions that can be attributed directly to the proposed action. This category of impact might be considered the "first-order" changes that result as a consequence of the action and identifies those effects that are immediate and obvious. In contrast, secondary impacts explain indirect or induced changes that result as a consequence of the action or its primary effects. Alterations of this type might be viewed as the "second-order" changes resulting from the project's perturbations.

A major aim of EIA involves the inclusion of environmental amenities into government decision-making. To incorporate amenity considerations into this process it becomes necessary to develop a complete understanding of the possible and probable consequences of the proposed action. Accomplishing this task suggests that EIA is more than a set of ideas or a terminology, but a method that seeks to:

- Develop a complete understanding of the proposed action.
- Gain a complete understanding of the affected environment.
- Project the proposed action into the future to determine its consequences.
- Report on the nature of the projected consequences attributable to the action in a manner that facilitate an informed trade-off between the action and its alternatives.

Fundamental to this method of analysis is the ability of the analyst to read the landscape and mentally overlay the action on its environmental setting. In the context of EIA, the environment is viewed as the whole complex of physical, social, cultural, economic, and aesthetic features, and for each the expected impacts are identified in relation to the project and its features.

Today, EIA is the embodiment of a systematic methodology for proactive decision-making that sets out to document, predict, and monitor human actions. Although EIA has a history dating back three decades, it remains very much an evolving methodology comprised of a mix of analytic techniques and administrative procedures that contrast in terms of purpose and comprehensiveness (Marriot, 1997). Because EIA continues to evolve there is considerable interest in improving assessment, with efforts concentrating on five main themes (Bartlett & Malone, 1993; Canter, 1993; Malik & Bartlett, 1993):

1 The development of analytic models used to guide the prediction of environmental consequences.
2 The refinement of procedures used to identify and reduce the effects of uncertainty.
3 The incorporation of new techniques that can accommodate subjective judgments and qualitative data.
4 The inclusion of cumulative impacts into the assessment.
5 The design of environmental monitoring programs for long-term project management.

Taken together, these themes identify common characteristics that should encourage more integrative approaches to EIA (Lein, 1998).

Perhaps the most important concept guiding EIA is that of disclosure. As a decision-making tool, EIA is, in essence, a process of bringing the environmental consequences of a proposed action to the attention of both decision-makers and concerned members of the public, making those effects known and providing the opportunity for comment and review of their significance. Theoretically, disclosure unfolds as a continuous sequence of analytical stages that culminate with the formal documentation of effects. Documentation takes the form of a written report that serves as the primary decision tool and communication device that connects the proposed action to all concerned parties. While the assignment of EIA to a single sequence of analytical procedures may not be a suitable generalization in all circumstances, its conceptual foundation is firmly rooted in the EIA planning process (Lawrence, 1994). Barrett and Therivel (1991) have defined this ideal as a unifying approach to impact analysis that:

- Applied to all projects that are expected to have a significant environmental impact.
- Compares alternatives to proposed project management techniques and mitigation measures.
- Results in a clear documentation of effects that conveys the importance of the likely impacts and their characteristics to experts and non-experts alike.
- Includes broad public participation and stringent administrative review procedures.
- Is timed in a manner that provides information for decision-makers and is enforceable.
- Includes mechanisms for post-EIA monitoring and feedback.

Realizing this ideal, however, underscores the contrast between EIA theory and practice (Lawrence, 1994). The practice of EIA has been substantively aided by a heightened emphasis on the use of scientific principles, procedures, and knowledge that recognizes the importance of explicit study design, assumption testing, and the clear establishment of spatiotemporal boundaries (Beanlands, 1989; Malik & Bartlett, 1993). The focus on EIA as science has contributed to the view of impact prediction and measurement as a set of rigorous and reproducable techniques guided by the studied application of expert judgment and experience (Lawrence, 1994; Lein, 1993b). Viewing EIA as science reduces the problem of assessment to four general considerations:

1 Careful selection and use of multiple social and natural environmental indicators.
2 Detailed concern for mathematical validity.
3 Applications of statistical tests of significance.
4 Sensitivity to data reliability, systemic bias, and nonlinear relationships.

It has been argued, however, that viewing EIA as a pure prediction of events is an unwise and unrealistic standard, since such a mindset tends to ignore the stochastic nature of human and environmental processes (DeJongh, 1988). Adhering to the principle that EIA is solely prediction tends to minimize the presence of uncertainty and encourages the assumption that a model exists to characterize every aspect of the assessment problem and that a single planning process can be applied uniformly to all projects. Lein (1993) discussed the implications of these assumptions, noting that prediction when applied to EIA implies the ability to foretell with bounded precision the future outcome of a given course of action. Reality suggests, however, that subjective-technical judgment and qualitative approaches are common to the practice of EIA. Therefore, conducting EIA in a purely predictive mode obscures the role played by expert judgment and discounts the inclusion of effects that cannot conform to this type of normative problem-solving. To some practitioners, expert judgment may seem to contradict the concept of EIA as science, yet its presence alludes to the realization that quantitative prediction may, in certain instances, be impossible, impractical, or inefficient (Lein, 1993b). Therefore, while a perfect quantification may not be a necessary condition of EIA, a structured problem-solving approach remains essential.

The method of EIA

Environmental impact assessment involves five basic activities:

- **Impact identification** – defining the task of identifying the impacts that need to be investigated. Although this seems like a relatively straightforward problem, there is a lack of knowledge concerning the nature and extent of impacts that frustrates this seemingly simple task. The environmental consequences that may be associated with an action in one location may be very different from an identical action located in another environmental setting. Thus, impact identification can be complex and continuous, yet before proceeding with a detailed assessment, preliminary identification of impacts is an absolute necessity. This early identification places a premium on project scooping and screening activities as a means of collecting information on the nature of the project and its environmental setting, and narrowing down the scale of an assessment to select those environmental factors critical to an understanding of the project's consequences.
- **Impact measurement and prediction** – this phase of EIA involves estimating the potential nature of environmental impact associated with the action expressed in quantitative and/or qualitative terms. Frequently, the magnitude of the possible changes attributed to a project must be predicted quantitatively. These predictions can be obtained in several ways, including the use of mathematical models, physical models, or computer simulations. Measuring the changes in the state of environmental factors is the first step in estimating the nature of impact. Once these measures are obtained they can be associated back to humans, plants, or animals to specify the exact nature of their effects in relation to these receptors.
- **Impact interpretation** – interpretation defines two distinct operations: (1) determining the significance of an impact and (2) evaluating the magnitude of an impact. For EIA to function as a decision tool, a clear distinction between magnitude and significance is necessary. In general, the magnitude of an impact is arrived at by prediction based on empirical measurements, significance tends to develop as an expression of the "cost" of the predicted impact to society (Thompson, 1990).
- **Impact communication** – following interpretation, the quantitative and qualitative information describing the impacts attributed to the proposed action need to be documented and presented in a form that enables experts and non-experts to understand and comprehend them. Because EIA carries the responsibility of full disclosure, effective communication is an essential ingredient. Unless decision-makers and concerned members of the public can understand the assessment, informed conclusions cannot be reached and the relative merits and risks associated with the project cannot be fairly evaluated.
- **Impact monitoring and mitigation** – minimal attention has been given to comprehen-

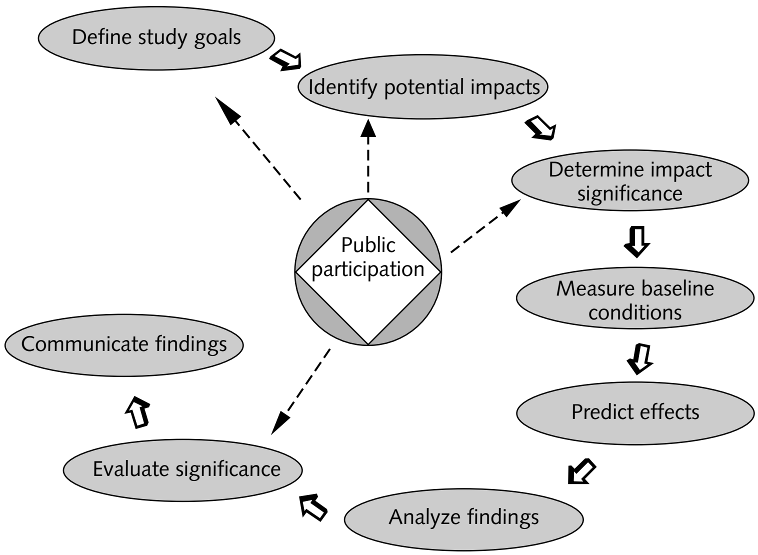

Fig. 10.1 The general method of environmental impact assessment.

sive environmental monitoring in conjunction with the EIA process (Canter, 1993). Three forms of environmental monitoring can be employed throughout the life-cycle of a project: (1) baseline monitoring, which defines the measurement of environmental variables to help determine existing conditions, (2) effects monitoring, which describes the measurement of environmental variables during project construction and operation to signal changes caused by the action, (3) compliance monitoring, which explains the periodic sampling or continuous measurement of project behavior to ensure developmental conditions are observed and environmental performance standards are met.

The five elements of EIA outlined above fit into a highly stylized procedure that suggests the sequence of tasks that are performed when conducting an EIA (Fig. 10.1). Beginning with the definition of goals, project assessment moves in an interactive fashion through the identification, measurement, and prediction phases, and culminates with the evaluation of significance and the documentation of effects. Within each of these phases, a series of subtasks can be described that complete the detailed methodology that has become the EIA process (Table 10.1). Typically, it is within these more detailed aspects of EIA that the link to decision-making can be understood. However, regardless of the type of project involved, the goals directing EIA remain constant: to identify impacts, to evaluate their importance, and to communicate concerns regarding the project and its alternative. To understand these goals we can return

Table 10.1 The phases of EIA.

Phase 1	*Organization/Screening and Scoping* • define study goals • identify potential impacts • determine impact significance
Phase 2	*Measurement and Analysis* • measure baseline conditions • predict effects of actions • estimate likelihood of predictions/forecasts • summarize and analyze findings
Phase 3	*Evaluation and Review* • evaluate findings • examine alternatives • evaluate mitigation strategies
Phase 4	*Communication and Documentation* • describe findings • communicate results • decide on proposed action
Phase 5	*Post-Impact Review* • implement monitoring program • modify/mitigate actions

to the pivotal legislation that formalized EIA, the USA National Environmental Policy Act (NEPA).

EIA and NEPA

Environmental impact assessment has evolved and diffused from its initial beginnings, yet the US National Environmental Policy Act of 1969 remains as the cornerstone for the approach to the management of change (Clark, 1997). The National Environmental Policy Act of 1969 (NEPA) was the first legislation of its kind to be adopted by any national government and has been widely emulated; however, few statutes are as intrinsically important and so poorly understood as NEPA (Caldwell, 1997). The fundamental purpose of NEPA was twofold. First, NEPA declared a national policy to protect and promote environmental quality. As stated in title I, section 101 of NEPA, the US federal government is charged with the responsibility to use all practicable means and measures 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. From this broad statement of policy, the goals that direct EIA were enumerated:

- To fulfill the responsibilities of each generation as trustees of the environment for succeeding generations.
- To assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings.
- To attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- To preserve important historic, cultural, and natural aspects of our national heritage, and maintain wherever possible an environment which supports diversity and variety of individual choice.
- To achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities.
- To enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

These statements of policy are followed by a set of "action forcing" provisions beginning in section 102(2) of the act. Under this section, all federal agencies are required to make a full and adequate analysis of all environmental effects of implementing their programs or actions. This includes a directive requiring that all policies, regulations, and public law are interpreted and administered in accordance with NEPA, and that all federal agencies follow a series of steps to ensure that the goals of NEPA are met. This provision begins by asking that a "systematic and interdisciplinary approach" is used to facilitate the integrated use of the social, natural, and environmental sciences in decision-making. However, the most significant aspect of NEPA's action-forcing mandate is found in section 102(2)(C). Here, all federal agencies, where actions significantly affect the quality of the human environment, are required to prepare a detailed statement of environmental impact. The prescribed elements of this environmental impact statement (EIS) include assessment of

1 The environmental impact of the proposed action.
2 Any adverse environmental effects which cannot be avoided should the proposal be implemented.
3 Alternatives to the proposed action.
4 The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.
5 Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

These five directives establish the basis for the EIA process and suggest a generalized framework for conducting an assessment. The specifics of the EIS process were refined and expanded upon by the Council on Environmental Quality (CEQ) (an agency sitting off the executive branch created in title II of NEPA).

The Council on Environmental Quality has issues guidelines to clarify the procedures to follow when preparing an EIS, the contents to be included in an EIS, and provided definitions of terms used in the EIA process to reduce confusion and enhance communication. According to the CEQ guidelines, 8 major points are to be addressed in an EIS:

1 A description of the proposed action, a statement of its purpose, and a description of the project's environmental setting.
2 The relationship of the proposed action to land-use plans, policies, and controls for the affected area.
3 The probable impact of the proposed action on the environment.
4 The alternatives to the proposed action.
5 Any probable adverse environmental effects that cannot be avoided.
6 The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.
7 Any irreversible and irretrievable commitments of resources (natural, cultural, labor, materials).
8 An indication of what other interests and considerations of federal policy are thought to offset the adverse effect identified.

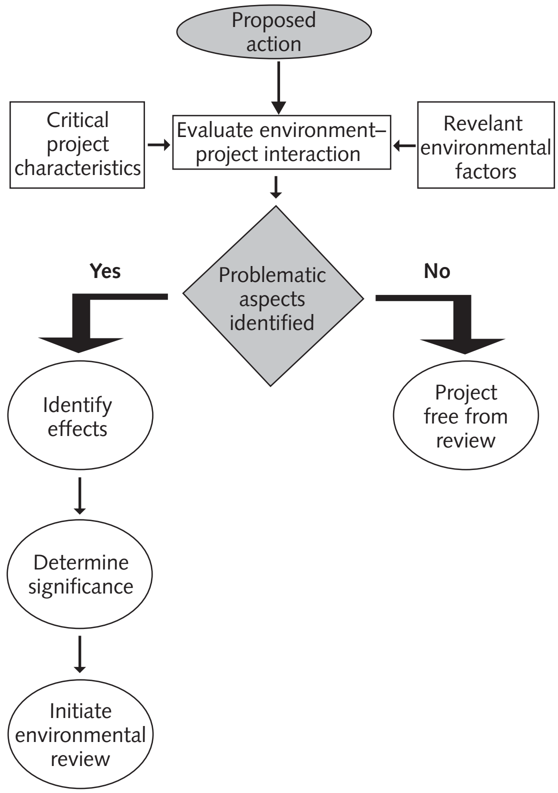

Fig. 10.2 The impact screening process.

Impact identification and screening techniques

The NEPA mandate specifically requires agencies to undertake a systematic approach to the assessment of environmental impacts and to develop methods and procedures to guide analysis. In the time that has elapsed since NEPA became law, a range of methods have been developed to assist with impact screening, identification, and forecasting (Bisset, 1988; Dickerson & Montgomery, 1993). Screening may be defined as the process of initial review that establishes a mechanism for the identification and selection of actions that require detailed analysis. As a technique, screening represents the first look at a proposed action and functions primarily to separate actions based on their probable effects. Thus, screening acts as a filter that ideally traps activities that should undergo more careful scrutiny. The general stages followed when screening proposed actions are illustrated in Fig. 10.2. The methodologies useful for this type of identification include interaction matrices, checklists, and more recently the use of expert systems (Canter, 1996; Lein, 1989). Interaction matrices range in sophistication from simple consideration of project activities and their impact on environmental factors to more detailed approaches that display interrelationships between impacted factors. Checklists range in complexity from simple listings of environmental factors that might be relevant given the proposed action, to descriptive approaches that include consideration of impact measurement. The applicability of these methods is summarized in Table 10.2.

While the methods presented in Table 10.2 can be useful, there is no universal approach that can be applied to all project types in all environmental

Table 10.2 Overview of impact screening methods.

Activity	Method	Utility
Impact identification	Matrices: *Simple*	High
	Stepped	Medium
	Networks	High
	Checklists: *Simple*	Medium
	Descriptive	Medium
Describing affected environment	Matrices: *Simple*	Low
	Stepped	Low
	Networks	–
	Checklists: *Simple*	High
	Descriptive	
Impact prediction	Matrices: *Simple*	Medium
	Stepped	Medium
	Networks	–
	Checklists: *Descriptive*	High
	Scaling/rating	Low
Selection of alternatives	Matrices: *Simple*	Medium
	Stepped	Low
	Checklists: *Scaling/rating*	Medium
	Checklists: *Weighed*	High
Summarization	Matrices: *Simple*	High
	Stepped	Low
	Checklists: *Simple*	Medium

Based on Canter (1996).

settings. For an EIA method to be useful it should be (after Lee, 1983):

1 Appropriate to the necessary tasks.
2 Relatively free from bias and reproducible.
3 Economical and flexible.

Since EIA methods do not provide complete answers to all questions related to a project or its alternatives, selection of the appropriate method should be based on careful evaluation and professional judgment. The appropriate technique is generally that method which helps to focus thinking, provide a simple organizational structure, enable the synthesis of information, and help evaluate alternatives on a common set of criteria.

Interaction matrix methods

The interaction matrix was one of the earliest EIA methods introduced into practice (Canter, 1996). Interaction matrices are two-dimensional tables that compare environmental attributes with project characteristics. By comparing the items listed along the row with the elements presented across the columns, project activities can be associated to the environmental factors they potentially disrupt. When a given action is expected to cause a change in a specific environmental factor, this relationship (interaction) is noted where the association intersects. The nature of the relationship can be treated by simply marking the interaction or by imposing a magnitude or importance rating. Interaction matrices fall into general classes: simple or stepped (Canter, 1996).

Simple matrix methods One of the more widely cited examples of a simple interaction method was introduced by Leopold et al. (1971). A matrix of this design lists specfic actions against environmental items. Where an impact is anticipated, a notation is made on the matrix that identifies the association; however, in this design each action and its impact is described in terms of its relative magnitude and importance. The logic is simple. Magnitude is expressed as an intensity along a 1 to 10 scale, with 10 representing a large magnitude and 1 a small magnitude. The importance of an interaction is related to its significance using a similar scaling system. While magnitude is based on an objective evaluation of factual information, importance scores are assigned on the basis of subjective judgment.

Stepped matrix methods Stepped matrices are commonly referred to as cross-impact matrices. These tools are often used to identify secondary and tertiary impacts associated with a proposed action. According to Canter (1996), a stepped matrix is one in which environmental factors are displayed against other environmental factors. Because stepped matrices facilitate the tracing of impacts, they are a useful means of describing causal sequences. However, as the levels of impacts and the types of actions increase, they can become difficult to interpret.

Checklist methods

Checklist approaches for impact identification range in complexity from basic lists of environmental factors to detailed descriptions that can include rankings or scaling of impact. Two checklist methods are common in EIA: simple checklists and descriptive checklists.

Simple checklist As the name implies, simple checklists are a basic accounting of the environmental factors that should be addressed in an assessment. Checklists provide a means to identify environmental factors that note areas of concern and help to prioritize and plan for more detailed studies.

Descriptive checklists Descriptive checklists provide detailed information on the measurement or prediction of impacts associated with environmental factors. For each item in the list, information is presented on possible environmental effects. In some cases, factor definitions are given and prediction methods are included.

In general, checklists offer a structured approach for identifying key impacts, together with background on key environmental factors that should be examined in the assessment. They also can be used to facilitate discussion and deliberation during the planning, implementation, and summary stages of the EIA process. However, to be effective, they must be carefully defined and documented, with weighting criteria and spatial boundaries clearly delineated.

Impact forecasting

Assessing the impact of a proposed action on the environment begins by projecting the action into the future and asking some fundamental questions about how the project will alter ambient conditions. Using the information gathered during the screening and scoping phase, a scenario is created that speaks to the basic "what ifs" a decision maker would need to understand before committing to the proposal. Not surprisingly, prediction is perhaps the most important technical activity of the EIA process and potentially the most confounding (Lein, 1993b). As noted previously, prediction when applied in EIA implies the ability to foretell with precision the future outcome of a specific course of action. There is also an expectation that the action and its environmental setting can be resolved in a deterministic manner, placing a reliance on deterministic logic and introducing an unnecessary bias into an analysis.

A solution to the prediction bias, offered by Culhane et al. (1989), is to replace "prediction" with the term "forecast." Although this shift may appear purely semantic, use of the term forecast suggests that conjecture rather than true insight or knowledge is involved in every case. The use of the term forecast also provides a perspective that can better accommodate the use of expert judgment and subjectivity without rendering an assessment invalid. Unfortunately, the notion of a forecast gives the impression that vagueness and imprecision can be condoned in an EIS. However, as Lein (1992) shows, vagueness and imprecision can be modeled and quantified to fit existing assessment methodologies in a manner that assists decision-making.

There are three principal methods used to forecast environmental impacts: (1) judgmental approaches, (2) physical models, and (3) numerical models. Each has its advantages and disadvantages, and no single method is preferred in all instances.

Judgment methods

It has been argued that the use of expert opinion in EIA is neither visible nor formal. While subjective judgment is a recognized characteristic of EIA, the conditions that direct its use are not clear. Commonly, judgmental forecasting relies heavily of the ability of experts to express their opinions and on the analyst's ability to structure or quantify those opinions into something meaningful. One means used to control and direct the application of opinion is the Delphi method. The Delphi method was developed to increase the effectiveness of experts making forecasts as a group. Through this technique, opinions are obtained from experts through the use of survey instruments. Expert responses are tabulated and statistical measures are derived and used to summarize and support a group conclusion.

Physical modeling

Physical models are small-scale three-dimensional representations of a physical system. By subjecting the physical model to the conditions described by an impact scenario the analyst can witness the potential consequence and evaluate possible mitigation measures to reduce the potential adverse effect.

Numerical models

Numerical models are constructed from a combination of algebraic or differential equations that summarize process relationships defined by a human, physical, or environmental system. Typically, numerical models are based on scientific laws, statistical relationships, or some combination of both. Through the use of numerical models a simulation experiment can be created that can be used to explore changes in critical environmental factors as defined by the process models used to represent them. The analyst can then alter parameters and variables in the model to examine interactions and success of various mitigation strategies.

Impact forecasting is made difficult by the complexity of the environmental system involved and the possible range of direct and indirect effects a project and its alternatives may produce. At its best, forecasting permits a narrowing down of the uncertainty related to a proposed action and provides estimates, qualitative and quantitative, of the potential changes that an action may induce. At its worst, forecasting can mislead decision-makers by overstating or under-reporting environmental impacts, and cast doubt over the entire assessment process. Although EIA enjoys a 30-year history, in many respects it can be viewed as a science still in its infancy. As we learn more about environmental change and human-induced changes in particular, the scope and practice of EIA will naturally evolve. Presently, three areas of concern have emerged that are actively reshaping the science of EIA: (1) the assessment of growth-inducing impacts, (2) the analysis of cumulative environmental change, and (3) the treatment of time.

Growth-inducing impacts

The term "growth-inducing impact" communicates different concepts to different professional disciplines. To establish a common starting point for this discussion, we can explain the concept of a growth-inducing impact from an environmental planner's perspective. From this point of view, such an impact can be defined as the degree to which a project promotes, facilitates, or provides for the increased urbanization and development of the environment surrounding the project. The significance of this concept is that it recognizes the indirect and secondary effects attributable to a project and how those effects can contribute to a larger and potentially unwanted series of regional environmental changes. Although the primary focus of this concept is on urbanization, one can apply the principle of growth inducement to other environmental factors as well. Thus it is possible to articulate induced growth in terms of increased demand for resources, increased pollution levels, and increased infrastructure requirements stemming from the project's regional influence.

When one is applying the term in EIA, a distinction has to be made between projects or actions that ***promote*** growth, ***facilitate*** growth, and/or ***provide*** for growth. This distinction is nontrivial and underscores the significance of considering the larger implications of a project in its regional setting. These distinguishing characteristics also suggest that different actions can produce growth-inducing effects with varying implications. To illustrate this point, consider the following rules of thumb:

1 Nonretail employment centers are considered to *promote* growth.
2 Ancillary development, such as residential, retail, and service centers *facilitate* growth.
3 Basic infrastructure, such as water supply systems, waste-water treatment facilities, and major transportation facilities, *provide* for growth.

The induced growth process suggested by these heuristics can be placed into context by considering a simple word model that describes how growth develops and assumes a geographic form:

Construction of a large source of employment like an industrial or office complex generates jobs that result in the construction of dwelling units in the vicinity: the addition of dwelling units induces retail development to locate in close proximity and generates demand for a range of community, cultural, and religious facilities. All of this activity requires the construction of streets and highways that improve accessibility to the area. Improved access fosters continued urban development, and each additional source of employment spurs a new round of development which perpetuates the growth cycle.

Positioning a proposed action on the simple growth model is one of the first steps in analyzing its growth-inducing impact and for identifying the mitigation strategies that are available to reduce the secondary and tertiary effects it will induce. In many instances, however, the spatial expression of growth is not the only point of concern in EIA. For example, in air quality analysis, the concern is not "growth" *per se*, but emission growth. Therefore, the relationship between growth, be it expressed in economic, population, or industrial terms, and its correlates, such as emission or effluent growth, must be evaluated in totality. Developing a "total" view of an action's environmental impact requires consideration of:

- Structural changes in urban land-use patterns.
- The expansion and intensification of urban densities.
- Loss of open space.
- Replacement of rural form with urban form.

A major concern, however, is that growth may not be the consequence of a single project, and identifying an individual action's contribution to an overall larger pattern can prove difficult. Additionally, changes in the environment can be generated by actions that do not require environmental review. Actions of this type have proved to be particularly vexing since little information is gathered about their influences and even less is understood about how their effects accumulate to produce a change in the environment.

Cumulative impact assessment

The traditional approach to EIA tends to concentrate on the identification and evaluation of a single proposed action on its environmental setting. Comprehensive analysis of the impacts of multiple human developments on the environment has been limited. According to the language of EIA, the term "cumulative impact" is used to refer to a "holistic" approach to environmental analysis. In fact, NEPA only indirectly addresses the concept of cumulative impact in its reference to the interrelations of all environmental components. The Council on Environmental Quality addressed the concept of a cumulative impact in its 1978 guidelines. In these guidelines CEQ defined the concept of a cumulative impact as the incremental impact of multiple present and future actions with individually minor, but collectively significant, effects taking place over a period of time. Thus, cumulative impact recognizes that environmental change can be produced not only by a single action, but by the total effect of multiple land uses and developments, including their interrelationships. The important distinction made is that impacts result as a consequence of the incremental impact of an action when added to future actions as well as the product of individually minor, but collectively significant, actions that were never subject to detailed EIA review. The concept also carries the implication that the total effect of separate actions on the environment may be substantively different than the simple summation of single project effects on the landscape.

In practice, cumulative impact assessment requires the analyst to step away from the single-project focus common to EIA and adopt a wide-angle view of the scale and pace of actions occurring within the planning region. The importance of this wide-angle view has been underscored by Hamann (1984). In this study, Hamann reported on the destruction of 4,000 ha of Florida wetlands over an 18-month period. The significance of this report was that the loss of wetlands resulted from projects that were all legally permitted by state and federal agencies. Although each project, when examined individually, did not pose a significant environmental threat, taken together they resulted in the substantial loss of a critical habitat.

The objective of cumulative impact assessment is to develop approaches capable of recognizing that although individual actions may have insignificant effects, in the aggregate they become significant. Several qualities of human actions become central to this type of assessment, particularly actions that are repetitive, aggregative, continuous, or time-delayed. Identifying actions that fall into one of these categories begins the process; however, different causes may exist that generate the cumulative effect. For example, if a given action is repetitive, its effects will be incremental. If other actions are occurring concurrently or planned in the future, they will collectively affect a given environmental attribute. Finally, some effects may be discernible after a time-delay, suggesting that effects may take years to accumulate to a measurable level. Cumulative impacts are therefore synergistic. This quality must be emphasized since it clearly separates cumulative impacts from primary and secondary impacts associated with a single action.

The general principle of synergism points to the realization that the whole is more than the sum of its parts in magnitude, severity, intensity, and complexity. Synergism implies interaction, combination, and new patterning that remains a challenge to assess. Although progress toward the development of methods to guide cumulative impact assessment has been slow, four elements have been noted that are critical to an analysis:

1 The nature of the inducing action.
2 The scale or extent of ongoing transformations.
3 The rate and timing of change.
4 The characteristics of the physical setting in which the actions are taking place.

A typology of cumulative effects has been derived that provides a structure for their investigation (Cocklin et al., 1992). From this classification system, 6 central characteristics can be noted to connect an action to its relationship to cumulative change (Spaling & Smit, 1993):

- **Time crowding** – characterized by frequent and repetitive environmental changes that cause the temporal capacity of an environmental medium to be exceeded.
- **Space crowdings** – resulting from a high spatial density of environmental change that alters a region's spatial pattern or processes.
- **Compoundings or synergisms** – occurring when two of more environmental changes contribute to another environmental change.
- **Time lags** – where there are delays between exposure to a perturbation and response.
- **Space lags** – where environmental changes appear some distance from their source.
- **Thresholds** – exceeding critical levels that cause disruptions to environmental processes that fundamentally alter system behavior.

From these analytical foci, the forecasting techniques needed to assist with the cumulative assessment problem are those that can compile information, direct the application of expert judgment, and track trends and deviation in environmental processes. The general forecasting methods available are summarized in Table 10.3.

Table 10.3 Forecasting methods to support cumulative impact assessment.

Method	Example
Intuitive and holistic methods	Conjecture Brainstorming Delphi techniques Heuristic programming
Scenarios and metaphors	Growth metaphors Historical analogies Scenarios Alternative futures
Extrapolation	Social trend analysis Monitoring Time-series analysis Economic forecasting models
Simulation and modeling	Structural modeling Dynamic modeling Simulation Systems analysis
Decision trees	Judgment theory Relevance trees Contextual mapping

The issues surrounding cumulative impact assessment and the question of growth-inducing effect shows that every analysis undertaken within the context of EIA has an implied temporal component. However, in most instances, the time horizon over which the EIA extends is never fully defined. The temporal ambiguity of EIA is even seen in NEPA and the CEQ revisions, where the analyst is asked to consider the "long term" but no specific time reference is provided. As human actions pose the possibility of carrying effects well beyond the time horizons of most environmental and comprehensive plans, a mechanism is needed that articulates time more strongly and uses time to evaluate how plans and actions will perform well into the future.

Time and the long term

Questions regarding the irreversibility of human impact and the long-term viability of environmental systems threatened by human activities have been difficult to resolve (Lein, 1992). Characterizing human impact requires a set of variables as diverse and complex as those governing the environmental system under consideration. Complicating matters is the high level of uncertainty that surrounds environmental processes and the form, diffusion, and persistence of human impact. The speed with which modern technology is developing assures that decisions made by society will increasingly risk affecting environmental systems well beyond the planning horizons of present-day policy-making institutions (Malone, 1990). This observations is evidenced in the controversies surrounding recent concerns over global warming, biodiversity, nuclear waste disposal, hazardous waste management, and habitat destruction. Such issues have tremendous implications for future societies that may be asked to adapt to an environmental systems that has shifted to a new equilibrium. To meet this challenge, new methodologies must be developed to evaluate the impact of human actions that may have environmental consequences that extend for periods of 100 to 10,000 years or more.

Environmental impact assessment has been the principal method for understanding human impacts on the environment within a structured decision-making framework. However, EIA traditionally emphasizes short-term impacts. The short-term nature of EIA was identified in a study conducted by Coates and Coates (1989). In this study the authors concluded that the existing concepts and methods that guide impact assessment are inadequate when effects over time periods exceeding 50 to 100 years are considered. Although forecasting is an important aspect of the process, the primary role of EIA is to guide decision-makers in making an informed trade-off among conflicting features of a proposed action (Culhane et al., 1989). As a result, EIA tends to be deficient in providing decision-makers with defensible forecasts when human actions and the environment are viewed in concert over the long term (Duinker & Baskerville, 1986).

In light of recent controversies regarding the nature of human impact on regional and global systems, and the increased potential modern society displays for engendering irreversible changes in vital Earth-system processes, a model is sought that can forecast the long-term nature of human action and constructions, communicating their implications at some future state of the environment. The emerging technique of environmental performance assessment holds promise in this regard, although tractable methods for conducting such studies remain in the developmental stages.

The environmental performance assessment

The concept of environmental performance assessment has been most fully developed within the context of high-level nuclear waste repository siting in complex geologic settings (Malone, 1990; Lemons & Malone, 1988). Using nuclear waste disposal as a backdrop, a performance assessment provides a quantified description of a system's current behavior, its expected future behavior, and the acceptability of that behavior when compared to a set of standards that specify the degree of safety required in the system over time. Conducting the performance assessment entails a detailed analysis and documentation of the processes, events, and uncertainties that could act to destabilize a nuclear waste repository site; it also entails identifying the potential consequences of one or more destabilizing events and their likelihood of occurrence. Given this information, the ability of a site to "perform" in accordance with a set of safety (performance) standards can be evaluated before the site is committed to a use with irreversible cross-generational consequences.

With respect to the repository siting example, the spent nuclear fuel must remain isolated from the biosphere for a minimum of 10,000 years, and a site must remain geologically stable while environmental processes and potential human interference act on the location over time. Clearly, this is a decision task well beyond the scope of EIA. Considering the magnitude and risks associated with the siting problem, the question is not only whether a particular site, given its environmental characteristics, will perform, but whether the approach taken to evaluate its future state is adequate. To address these issues, an environmental performance assessment must focus on four critical aspects of a proposed action:

1. The risks associated with the environmental components that describe the site.
2. The interaction between environmental components as presently understood through the application of predictive models across the selected time horizon.
3. The nature and significance of uncertainty.
4. The impact and ramifications of a failure in performance.

Beyond the high-level waste disposal problem, similar situations can be described where prolonged exposure to human activities is threatening to drive environmental systems to a new state. In these situations environmental performance assessment can be expanded to include not merely an engineering system or construction, but also policy decisions whose implications may carry extended environmental consequences. The advantage of the performance assessment in these applications is its ability to focus on the mitigation measures available to reduce adverse consequences and to investigate whether mitigation will keep potential risks below environmental thresholds at extended time scales. In addition, the uncertainties associated with the action can be identified and environmental trends attributable to the action can be projected to explore various "failure" scenarios.

Conducting a performance assessment

Based on our previous discussion, environmental performance explains the quantified description of a system's present behavior, its expected future behavior, and the acceptability of that behavior in relation to a set of "performance" standards that will reduce the risk of adverse environmental consequences. The environmental performance assessment, therefore, involves two interrelated tasks:

1. The analysis and documentation of the processes, events, and uncertainties that influence long-term system behavior.
2. The identification of the potential consequences of one or more system events and their likelihood.

To be effective the performance assessment must provide information concerning the total reliability of the environmental components that characterize the site and their interaction. Brandstetter and Buxton (1989) have summarized the procedures followed to derive this information. In general, assessment consists of a series of iterative steps that begin with the collection of facts and data characterizing the planned construction and culminate in an estimate of confidence in the system's performance though sensitivity and uncertainty analysis. The basic outline for the method of long-term environmental impact forecasting involves:

1. Collecting facts and data characterizing the planned construction (action).
2. Developing conceptual and analytical models describing the relevant human–environmental interactions related to the construction.
3. Identifying the events (natural and human induced) that could trigger a failure in the system's performance.
4. Developing a series of scenarios that explain

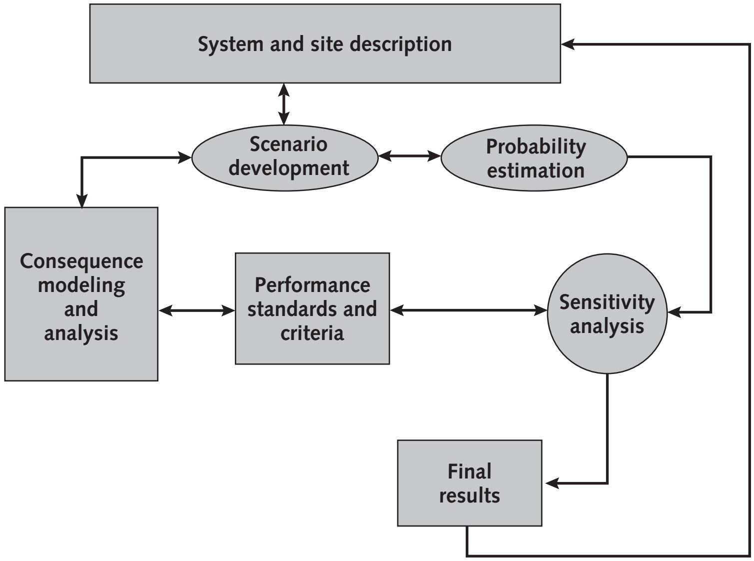

Fig. 10.3 Features of the environmental performance assessment process.

the event identified in (3) above, and detailing their consequences.

5 Selecting a set of credible scenarios and modeling their behavior over the analytic time horizon.
6 Evaluating the results of the modeling effort.
7 Reviewing and adjusting the construction as necessary to ensure its long-term performance effectiveness (safety).

The basic procedures presented above can be illustrated to reveal the overall flow of information through the process (Fig. 10.3). Perhaps the most critical stages in performance assessment involve developing conceptual and analytical models of human–environment interactions, identifying triggering events that could lead to a system failure, and detailing the consequences that could result from such failures. Processing through these stages leads to the selection and analysis of scenarios that provide decision-makers with a set of probability estimates surrounding the consequence of a given event/failure sequence.

Since the future is obviously difficult to understand, performance assessment provides a crystal ball that promotes a model-focused analysis that can be employed to examine the implications of technologies and actions that are capable of affecting future generations. However, while it is a promising tool, there are several unresolved issues that must be addressed in order to improve its wider application:

- Methods are needed for quantifying uncertainties associated with parameters characterizing natural systems.
- A rigorous objective approach is needed to assist with developing scenarios.
- Methods are needed for estimating probabilities and for measuring uncertainty.
- Systematic approaches are needed to guide the use of expert judgment.
- Validated computation models are needed to direct quantitative and predictive analysis of complex natural processes.
- Better understanding is needed of the uncertainties that influence the behavior of natural systems over long time periods.

As these issued are addressed, the planner's ability to look at change over extended time horizons will be enhanced and the challenges of the future placed within our grasp.

The continuing challenge

Environmental impact assessment and the emerging technique of environmental performance assessment identify methods that personify the proactive nature of environmental planning and the need to integrate "future thinking" into all aspects of the planning process. As the needs of modern society increase demand for land and other resources, maintaining balance between the human world and the environmental systems on which that world depends will remain a challenge. Meeting this challenge will require wisdom and creativity together with some fundamental changes in the way we look at our world. Change, however, is something difficult to conceptualize and even more difficult to accept; yet the need to plan for change is greater now than ever before.

As we consider the implications of social and ecological perturbations resulting from shifting lifestyles and technical advancements over the past 25 years, we must begin to consciously and deliberately continue our pursuit of a new system of physical order, bridging the local with the global, and taking full advantage of the data and information that has been acquired to guide us. The missing ingredient is a systematic and considered approach to the issues that evidence change. Fortunately the natural environment offers us numerous examples and models we can follow. Thus, by beginning simply, societal awareness can be enhanced and may show us that while complex, the environment is not complicated. Solutions are possible; we simply need to look for them.

For the last decade, it has been convenient to view environmental issues as "global" – distancing ourselves from the problems and placing responsibility for them on an abstraction removed from our day-to-day reality. In actuality few environmental problems are global or national. While their total effect may be reflected at these scales, their origins are closer to home and ultimately the product of individual decisions made in places most tend to ignore. Urban patterns expand because we live in dispersed settlements that are removed from the disamenities of urban life. Water supplies become scarce because we enjoy using this resource in wide and varied ways. Farmland disappears because we fail to recognize that these are the places our food comes from. We build on steep slopes because we like the view. We consume natural habitat because we have our own habitat needs. These local decisions color the environmental problem, direct how the planning process responds, and influence what our future will look like. The forgotten element in all this is that it is our future, and each of us helps to shape and guide the changes it will reveal. To be effective, each of us must contribute to a greater understanding of the environment, learning from the landscapes we inhabit and applying those lessons to select alternatives that will build toward a sustainable future. Here, we can recall a simple paragraph taken from Aldo Leopold's *A Sand County Almanac* written some 50 years ago:

> *The last word in ignorance is the man who says of an animal or plant: "What good is it?" If the land mechanisms as a whole is good, then every part is good, whether we understand it or not. If the biota in the course of time, has built something we like, but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.*

Intelligent tinkering begins with a plan and the synthesis of information regarding the environment, its opportunities, constraints, and risks that will communicate ecologically sound principles to decision-makers and recommend only that course of action that makes a difference in a manner that fits logically and naturally into our lives. This is the challenge, and it has been the aim of this text to provide directions to the point where this journey begins.

Summary

The proactive nature of environmental planning directs us to examine the characteristics of a proposed plan or project before committing to an irreversible outcome that may carry serious environmental consequences. Consideration of the qualities of a plan or proposed action superimposed onto the natural system and projected into an uncertain future is the subject of this chapter.

Two important recipes for assessing the future were described: environmental impact assessment and environmental performance assessment. As defined in the US NEPA, EIA requires a detailed analysis of all federal actions that significantly affect the quality of the human environment. Approaches followed when conducting such an analysis were explored. Yet EIA alone does not provide sufficient guidance, particularly when time scales exceed 100 years. When confronted with time-extensive problems, environmental performance assessment provides a methodology for evaluating long-term risk. Although it is still an emerging technique, along with EIA it is an important tool to reduce uncertainty and better understand the potential ramifications of a human decision. Yet the challenges to develop sustainable plans and reduce the entropic effects of human actions remains great.

Focusing questions

Explain the importance of disclosure in EIA.

Outline the fundamental activities that define the method of EIA.

Compare and contrast growth-inducing impacts with cumulative impacts; how can they be identified?

Explain the basic steps involved in long-term impact forecasting.

How might techniques such as performance assessment and EIA reshape environmental decision-making?