CUMULATIVE EFFECTS ASSESSMENT

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CHAPTER 1

INTRODUCTION

Although the terms "cumulative impacts" and cumulative effects" were used in the 1970s in several countries' environmental impact assessment (EIA) legislation, regulations, or guidelines, it was not until the mid-to-late 1980s that the terms began to be incorporated in practice. As contained herein, the two terms will be used synonymously. Accordingly, the purpose of this book is to present the state-of-the-art of the worldwide practice of cumulative effects assessment (CEA). The emphasis is on principles, procedures, methods, monitoring, and mitigation for cumulative effects. Illustrations from case studies are also included.

This introductory chapter highlights definitions, types of cumulative effects, and key principles of CEA. Chapter 2 is focused on several examples of step-wise procedures which can be used for project-level and broader-scale studies. Five special issues are addressed in Chapter 3, including delineating spatial and temporal boundaries, identifying "reasonably foreseeable future actions" in the environs of the proposed action, defining "baseline conditions," and determining the significance of predicted cumulative effects. Scoping as an analytical process in CEA is the subject of Chapter 4. Chapters 5 and 6 summarize both generic methods for cumulative effects identification and prediction methods for quantifying cumulative effects, respectively. Chapter 7 relates CEA to strategic environmental assessments. Several case studies related to CEA are summarized in Chapter 8. Chapter 9 contains an extensive case study focused on cumulative air quality effects at military installations. Relationships between surface water-focused impact studies, CEAs, and effluent trading programs (ETPs) are addressed in Chapter 10 along with expanded mitigation options provided by ETPs. The purposes of, and planning for, monitoring programs for key cumulative effects are the subjects of Chapter 11. Chapter 12 highlights biodiversity and ecosystem management as special issues in mitigation planning for cumulative effects. Numerous World-wide Web sites related directly or indirectly to CEA are identified in Chapter 13. Finally, Chapter 14 includes a discussion of barriers and research needs related to CEA.

The refereed journal articles, reports, papers, and books used in the preparation of this book were identified from computer-based literature searches and contacts with professional colleagues throughout the world. Literature searches of several databases (Biosis, NTIS, Enviroline, and Water Resources Abstracts) were conducted in 1992, 1994, and 1996. Professional colleagues provided information via questionnaire surveys (Burris, 1994; and Cooper, 1995) and contacts at professional conferences and training courses. As part of this process, several extensive bibliographies of articles, reports, papers, and books related to cumulative effects and CEA were identified; examples include Peterson, et al. (1987), Sonntag, et al. (1987), Williamson and Hamilton (1989), Kennedy (1994), Council on Environmental Quality (1997a), and Cumulative Effects Assessment Working Group (1997).

IMPORTANCE OF CEA

Three examples of recent studies which identified the importance and challenges related to CEA will be highlighted. Although two of the three

derive from a single-country emphasis, they all have implications both nationally and internationally. The first involved a 1994 questionnaire survey to ascertain the perspectives of academia regarding the strengths and limitations of the National Environmental Policy Act (NEPA) and the EIA process in the United States (Canter and Clark, 1997). The survey was part of a comprehensive study of NEPA effectiveness and efficiency conducted in conjunction with the 25th anniversary of NEPA. The survey participants included 31 academicians comprised of 12 different disciplines from 21 states; the majority of the participants had over 20 years of experience in teaching, research, and professional practice related to the NEPA process. Several strengths of NEPA were identified; the two most important were that NEPA encourages agencies and decision makers to acknowledge potential environmental consequences to the public, thus opening up the decision-making process; and to think about environmental consequences before environmental and/or fiscal resources are committed. The survey participants also prioritized topical issues needing improvement; two high priority ones were the need for methodological approaches for addressing cumulative effects and reductions in institutional barriers related to the analysis of cumulative effects. Specific recommendations related to CEA were that the Council on Environmental Quality (CEQ) produce a handbook for practitioners on how to conduct CEA, that training workshops be held based on the handbook, and that the guidelines for CEA documentation in EAs (environmental assessments, or "preliminary studies") and EISs (environmental impact statements, or "comprehensive studies") be developed, with particular emphasis given to connected actions and how they should be addressed. The handbook was published in early 1997 (Council on Environmental Quality, 1997a); however, the other recommendations have not been accomplished.

The CEQ in the United States recently issued the summary results from the above noted comprehensive study of NEPA (Council on Environmental Quality, 1997b). Based on inputs from several hundred EIA professionals in governmental agencies, the private sector, consulting, and academia, it was determined that the greatest benefit of NEPA is its provision of a framework for collaboration between federal agencies and those individuals and groups subject to the environmental impacts of agency decisions. The report also noted that five elements are critical to the continuing improvement of the NEPA (EIA) process; one was the use of an interdisciplinary place-based approach in information analysis and synthesis, including attention to CEA. Of particular importance is the need to use appropriate methods and tools for CEA, with the ongoing challenge being to refine approaches and to realize that a better decision rather than a perfect analysis of cumulative effects, is the goal of NEPA and EIA professionals.

Additionally, the recently completed International Study of the Effectiveness of Environmental Assessment integrated trends, needs, and opportunities in EIA. The 1993-96 study identified four challenges related to strengthening the practice of EIA (Sadler, 1996): (1) establishing standards for quality performance in EIA, for example, through codifying international guidelines and principles; (2) upgrading EIA processes and activities, notably to improve quality control, public involvement and the consideration of cumulative effects; (3) extending strategic environmental assessment (SEA) as an integral part of decision making, through the development of practical guidance materials; and (4) sharpening SEA as a sustainability instrument through the use of pilot projects. Regarding methods for CEA, those that focus on source-effect linkages based on a limited number of common denominators were noted as desirable. In this context, "sources" denote the pattern and timing of activities that cause or will potentially initiate environmental change, while "effects" denote the syndrome of impacts and long-term changes that occur in response to perturbation and stress. Challenges related to CEA

include documenting case experience (success stories) on how these issues can be addressed, institutionally and methodologically, at the project and at strategic levels.

As a further observation, as the scope of the EIA process is expanding to include socio-economic impacts along with impacts on the biophysical environment, as well as larger-scale issues such as biodiversity changes, sustainable development, economic valuation of natural resources and impacts, acid rain, and global climate change, the importance of incorporating CEA within the process is increasing (Rees, 1995). Appropriate consideration of global climate change within NEPA analyses has been addressed by Cushman, et al. (1989). Sustainable development considerations and their incorporation within the EIA process, including within CEA, represent an emerging theme in the practice of EIA. For example, Barrow (1997) indicated that CEA broadens the focus of project-level EIA and is important in the context of incorporating sustainable development concerns within the EIA process. Further, Lawrence (1997) suggested that environmental sustainability should be addressed within CEAs conducted at both project and strategic levels of analysis. Due to the broader focus of strategic environmental assessments (SEAs) on policies, plans, and programs, it is vital that such studies incorporate cumulative effects concerns.

In a related example, watershed-related planning has come to the forefront in recent years within the United States. Such planning is being used to examine point and nonpoint sources of pollution in river basins or segments thereof, as well as current and future water uses under a variety of development scenarios. Watersheds are also being used as geographical boundaries for effluent trading programs. Cumulative effects considerations should logically be incorporated in watershed planning and management efforts.

Cumulative effects should also be incorporated into social (or socio-economic) impact assessment (SIA) (Barrow, 1997). However, due to the historical attention directed to bio-physical impacts, SIA is not a part of the EIA process in all countries. Further, and as will become evident herein, CEA practice to date has been primarily focused on effects on environmental media and natural biophysical resources, including valued ecosystem components (VECs).

DEFINITIONS OF KEY TERMS

Cumulative impacts, cumulative effects, and cumulative environmental changes are terms which are often used interchangeably (Spaling, 1997). However, there are a range of considerations included in these terms. For example, the following definitions have been promulgated for the terms "cumulative impacts" or "cumulative effects":

(1) Cumulative impacts refer to the accumulation of human-induced changes in valued environmental components across space and over time; such impacts can occur in an additive or interactive manner (Spaling, 1997).

(2) Cumulative impacts are effects which combine from different projects and which persist to the long-term detriment of the environment (Gilpin, 1995).

(3) Cumulative effects refers to progressive environmental degradation over time arising from a range of activities throughout an area or region, each activity considered in

(2) CEA is the process of systematically analyzing and evaluating cumulative environmental change (Spaling and Smit, 1993).

(3) CEA should address several issues such as time and space crowding of perturbations and synergisms. The following definition encompasses these and other issues (Court, Wright, and Guthrie, 1994): cumulative effects assessment involves predicting and assessing likely existing, past and reasonably foreseeable future effects on the environment arising from perturbations which are time and/or space-crowded, synergisms, indirect, or constitute nibbling. Time crowding refer to perturbations which are so close in time that the effects of one are not dissipated before the next one occurs. Space crowding relates to perturbations which are so close in space that their effects overlap. Different types of perturbations occurring in the same area which may interact to produce qualitatively and quantitatively different responses by comparison to the receiving environment are called synergisms. Cumulative effects can also be produced at some time or distance from the initial perturbation, or by a complex pathway; these are called indirect effects. Finally, "nibbling" refers to small changes from multiple similar actions.

(4) CEAs are typically expected to (Cumulative Effects Assessment Working Group, 1997): assess effects over a larger (i.e., "regional") area that may cross jurisdictional boundaries; assess effects during a longer period of time into the past and future; consider effects on VECs due to interactions with other actions, and not just the effects of the single project under review; include other past, existing and future (e.g., reasonably foreseeable) actions; and evaluate significance in consideration of other than just local, direct effects.

(5) CEA is both holistic and integrative (Duinker, 1994). Holistic suggests that the potential impacts of the proposed action and nearby past, current, and future actions are considered. Integrative suggests an environmental component perspective; for example, a natural ecosystem "integrates" the impacts from various actions and adapts in response to the stresses.

The above definitions of CEA are wide ranging; however, they tend to be focused on the process of identifying and quantifying cumulative effects, and on appropriate considerations in assessing the significance of such effects. Necessary environmental management (including monitoring of cumulative effects as well as implementation of mitigation strategies) within the spatial and temporal boundaries is not stressed; however, such emphases may be the most important aspects of CEA. For example, Vestal, et al. (1995) suggested that the larger goal of CEA is to develop appropriate management strategies for cumulative effects (Vestal, et al., 1995). Further, Williamson (1993) noted that the combined objectives of CEA and resource management planning are: to generate logical, scientific, and timely problem (cumulative effects) analyses; to bring agencies together collaboratively to develop an overall management plan and proactive, measurable resource goals; and to meld those results into comprehensive species and habitat maintenance and enhancement blueprints for the ecosystem of concern.

CEA is specified in the EIA legislation of several countries. Four examples are Australia (Court, Wright, and Guthrie, 1994), Canada (Drouin

and LeBlanc, 1994), New Zealand (Dixon and Montz, 1995), and the United States of America (Council on Environmental Quality, 1997a). Country legislation, regulations, and/or guidelines may either directly specify CEA, or they may infer that cumulative effects should be considered within the EIA process. The fundamental premise in relevant legislation/regulations/guidelines is that CEA is an issue that should be an integral part of the EIA process (Burris and Canter, 1997b). In other words, CEA should typically be included as part of an EA or EIS for a proposed action, and not as a separate study or separate EA or EIS (Kreske, 1996). However, in the absence of specific regulations or guidelines which define "triggers" for initiating CEA, the decision to actually conduct a CEA within the EIA process for a proposed project may be driven by actual or possible declines in potentially affected natural resources (Williamson, 1993). In this situation, separate studies of experienced cumulative effects in relevant geographical areas may serve as such "triggers." Three examples of these types of separate studies are listed in Table 1.1. The studies listed in Table 1.1 may have been prompted by other environmental laws; for example, water quality control laws. Further, cumulative effects could be directly or indirectly included in air quality laws as well as resource protection and species protection laws.

TYPES OF CUMULATIVE EFFECTS

Cumulative effects can result from multiple pathways and be manifested on both biophysical and socio-economic resources. Table 1.2 illustrates the range of types of cumulative effects (Council on Environmental Quality, 1997a). The CEQ definition of cumulative effects is primarily related to multiple actions and both additive and interactive processes. As a further illustration of the importance of the analysis of pathways in CEA, Peterson, et al. (1987) suggested a systematic typology as shown in Figure 1.1. The identified pathways are self-explanatory; for example, Pathway 2 includes biomagnification of chemicals within various organisms associated with terrestrial or aquatic food chains. Finally, Barrow (1997) summarized cumulative effects into the following categories:

(1) incremental (additive) (repeated additions of a similar nature a + a + a + a ...);

(2) interactive processes (a + b + c + n ... results in a significant impact);

(3) sequential effects;

(4) complex causation;

(5) synergistic impacts;

(6) impact occurs when a threshold is passed as a consequence of some 'trigger effect' (e.g., 'chemical time bomb' or 'biological time bomb');

(7) irregular 'surprise effects'; and

(8) impacts triggered by a feedback process ('antagonistic' - feedback which reinforces a trend; or 'ameliorative' - feedback which counters a trend).

Table 1.1: Examples of Studies on Experienced Cumulative Effects from Multiple Projects/Activities

Case Study	Reference
Cumulative effects on aquatic ecosystems in the Peace, Athabasca, and Slave River basins in Alberta, Canada	Wrona (1996)
Cumulative effects on phytoplankton of phosphorus loading reductions and the invasion of zebra mussels in Lake Erie in the USA	Nicholls and Hopkins (1993)
Cumulative effects on benthic macroinvertebrates, rooted aquatic plants, migrating birds, and mink in the ecosystem of the upper Mississippi River in the USA	Wiener, et al. (1995)

Table 1.2: Types of Cumulative Effects (Council on Environmental Quality, 1997a)

	Additive Process	Interactive Process
Single Action at project level	Type 1 -- Repeated "additive" effects from a single proposed project. Example: Construction of a new road through a national park, resulting in continual draining of road salt onto nearby vegetation.	Type 2 -- Stressors from a single source that interact with receiving biota to have an "interactive" (nonlinear) net effect. Example: Organic compounds, including PCBs, that biomagnify up food chains and exert disproportionate toxicity on raptors and large mammals.
Multiple Actions Cumulative effects	Type 3 -- Effects arising from multiple sources (projects, point sources, or general effects associated with development) that affect environmental resources additively. Example: Agricultural irrigation, domestic consumption, and industrial cooling activities that all contribute to drawing down a ground water aquifer.	Type 4 -- Effects arising from multiple sources that affect environmental resources in an interactive (i.e., countervailing or synergistic) fashion. Example: Discharges of nutrients and heated water to a river that combine to cause an algal bloom and subsequent loss of dissolved oxygen that is greater than the additive effects of each pollutant.

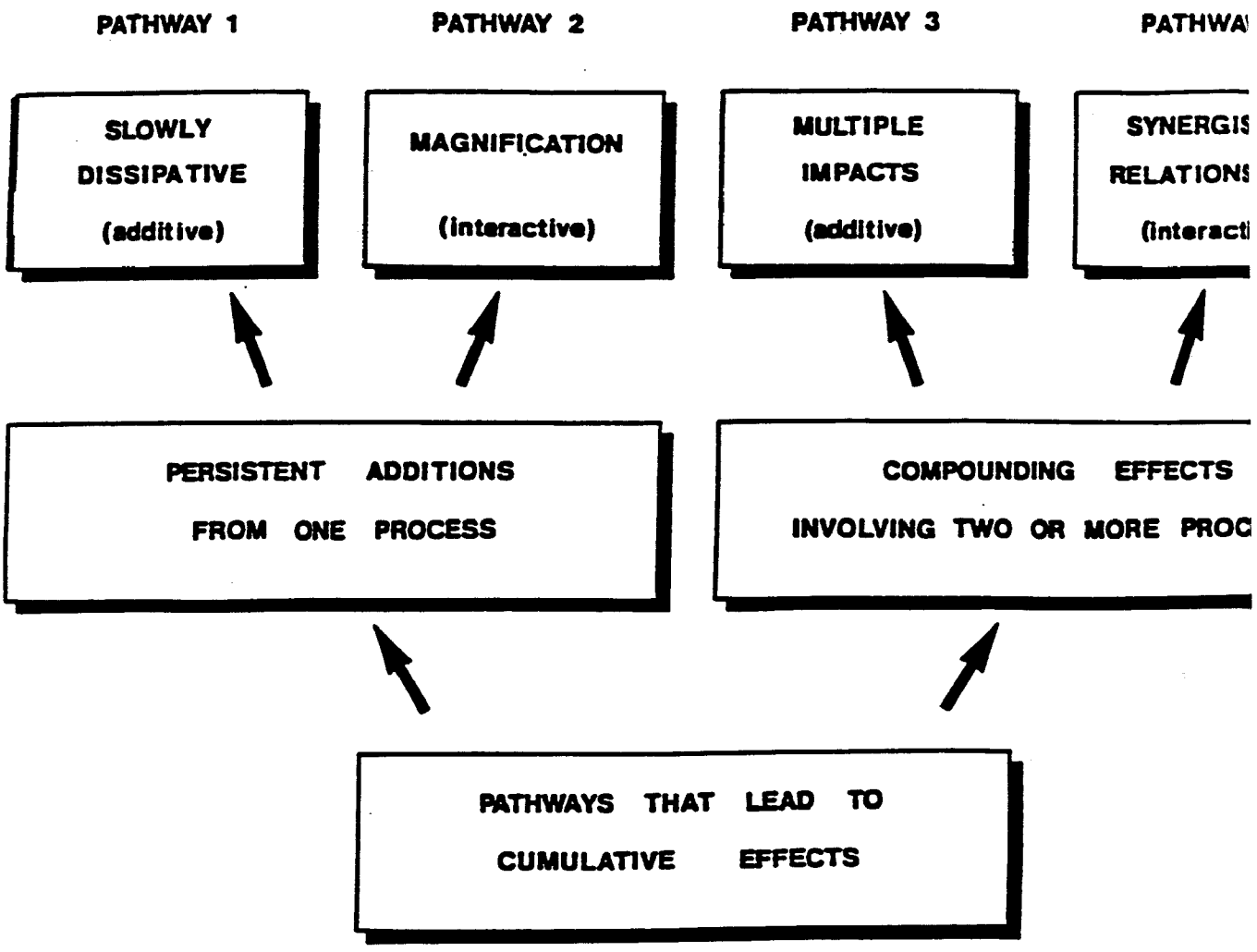

Figure 1.1: Basic Functional Pathways That Contribute to Cumulativ Effects (Peterson, et al., 1987)

PRINCIPLES OF CEA

While there may be variations in the definitions and terminology associated with cumulative effects, most efforts to incorporate CEA within the EIA process have focused on considering the proposed action in relation to surrounding projects; appropriately defining the baseline conditions; and addressing combined effects from the proposed action and surrounding activities on environmental media, natural resources, and socio-economic systems. Regarding EIA practice in the United States, eight principles as shown in Table 1.3, along with related descriptive paragraphs, have recently been delineated for conducting CEAs (Council on Environmental Quality, 1997a). The principles were derived from the definition of "cumulative impacts" in the CEQ regulations, from surveys of the experiences of EIA practitioners, and from a review of published literature. They should be considered in the planning and conduction of CEA within the EIA process. Further, they routinely refer to resources (such as air, surface water, ground water, timber, fisheries, etc.), ecosystems (such as wetlands and coastal zones), and human communities (the socio-economic environment). Finally, the principles are sufficiently generic so that they can be applied in the worldwide practice of CEA. Further, they can be applied to the specific actions of individual governmental agencies.

Although not specifically stated, the 8 principles listed in Table 1.3 will require the collaboration of multiple governmental agencies if they are to be effectively applied in CEAs. Such collaboration can be achieved via scoping and informal meetings, as well as through the development of bi-lateral to multi-lateral cooperative agreements between agencies. Of particular importance is the need for collaboration and cooperation in conjunction with monitoring cumulative effects and the implementation of appropriate mitigation programs.

SUMMARY

The following key points summarize the topics addressed in this introductory chapter:

(1) The interest in and incorporation of CEA within the EIA process is being increasingly recognized for both project-level and strategic-level impact studies. It is vitally important that CEA be within and not separate from the EIA process.

(2) A key word used herein is "multiple." For example, there are multiple definitions of cumulative effects and CEA, with the outcome being the need to recognize multiple actions, pathways, receptors, and types of effects when cumulative effects considerations are included in the EIA process.

(3) CEA principles suggest the need for a broadened perspective on effects, including the need for effective scoping, recognition of transboundary concerns, and incorporation of the concept of carrying capacity regarding affected resources, ecosystems, and human communities.

(4) Institutional collaboration and cooperation will be needed for managing cumulative effects, with the term managing including both monitoring and the use of effective mitigation programs.

Table 1.3: Principles of Cumulative Effects Assessment (Council on Environmental Quality, 1997a)

1.	*Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions.* The effects of a proposed action on a given resource, ecosystem, and human community include the present and future effects added to the effects that have taken place in the past. Such cumulative effects must also be added to effects (past, present, future) caused by all other actions that affect the same resource.
2.	*Cumulative effects are the total effect, including both direct and indirect effects, on a given resource, ecosystem, and human community of all actions taken, no matter who (federal, nonfederal, or private) has taken the actions.* Individual effects from disparate activities may add up or interact to cause additional effects not apparent when looking at the individual effects one at a time. The additional effects contributed by actions unrelated to the proposed action must be included in the analysis of cumulative effects.
3.	*Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and human community being affected.* Environmental effects are often evaluated from the perspective of the proposed action. Analyzing cumulative effects requires focusing on the resource, ecosystem and human community that may be affected and developing an adequate understanding of how the resources are susceptible to effects.
4.	*It is not practical to analyze the cumulative effects of an action on the universe; the list of environmental effects must focus on those that are truly meaningful.* For cumulative effects analysis to help the decisionmaker and inform interested parties, it must be limited through scoping to effects that can be meaningfully evaluated. The boundaries for evaluating cumulative effects should be expanded to the point at which the resource is no longer affected significantly or the effects are no longer of interest to affected parties.
5.	*Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries.* Resources typically are demarcated according to agency responsibilities, county lines, grazing allotments, and other administrative boundaries. Because natural and sociocultural resources are not usually so aligned, each political entity actually manages only a piece of the affected resource or ecosystem. Cumulative effects on natural systems must use natural ecological boundaries and analysis of human communities must use actual sociocultural boundaries to ensure including all effects.

Table 1.3 (continued):

6.	*Cumulative effects may result from the accumulation of similar effects or the synergistic interaction of different effects.* Repeated actions may cause effects to build up through simple addition (more and more of the same type of effect), and the same or different actions may produce effects that interact to produce cumulative effects greater than the sum of the effects.
7.	*Cumulative effects may last for many years beyond the life of the action that caused the effects.* Some actions cause damage lasting far longer than the life of the action itself(e.g., acid mine drainage, radioactive waste contamination, species extinctions). Cumulative effects analysis needs to apply the best science and forecasting techniques to assess potential catastrophic consequences in the future.
8.	*Each affected resource, ecosystem, and human community must be analyzed in terms of its capacity to accommodate additional effects, based on its own time and space parameters.* Analysts tend to think in terms of how the resource, ecosystem, and human community will be modified given the action's development needs. The most effective cumulative effects analysis focuses on what is needed to ensure long-term productivity or sustainability of the resource.

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CHAPTER 2

PROCEDURES FOR CEA

This chapter is focused on several examples of pragmatic steps which can be used to plan and conduct a cumulative effects study as part of a project-level environmental impact assessment (EIA) or a strategic environmental assessment (SEA). The specific steps must be seen within a conceptual framework or planning context.

Conceptual frameworks for CEA typically include three components (Spaling and Smit, 1993): (1) a cause or source of change (or perturbations); (2) the process of change as reflected via the pertinent system structure and processes; and (3) the result of the change (or effect). Perturbations refer to naturally occurring events, or human-induced actions, over time and space which contribute to cumulative environmental change. System structure and processes include the receiving ecological, economic, and/or social systems affected by the perturbations, and the temporal and spatial processes influencing system response or recovery. Finally, effects denote the change in a system's structure and functioning over time and space.

Stakhiv (1988) suggested that the CEA paradigm within a regional planning context includes seven key components: (1) setting planning goals and objectives for future growth and management of the region; (2) developing a scientifically supportable analytical framework for assessing the cumulative effects of various growth and development scenarios; (3) setting goals for wetland or other natural resources conservation in relation to ecosystem needs; (4) forecasting anticipated growth to assess the resultant demand for services and resources; (5) developing rational analytical bounds for the ecological and social carrying capacity of an area; (6) assessing cumulative effects on a particular set of environmental resources, such as wetlands, with the effects being due to the sum of perturbations resulting from different actions; and (7) developing a framework for forecasting specific actions that characterize different growth and development scenarios.

STEP-WISE PROCEDURES

Several step-wise procedures have been developed for CEA; for example, Davies (1992) identified the following pragmatic steps for conducting a CEA:

(1) Define the boundaries of project related effects.

(2) Identify pathways through which the anticipated environmental effects of a project are expected to occur.

(3) Identify relevant past and existing projects and activities, their impacts on the environment of the proposed project(s), and the pathways through which those impacts occur.

(4) Identify future projects and activities and their potential linkages via impact pathways to the proposed project(s).

(5) Identify VECs that exist within the zone of influence of the proposed project(s).

(6) Through linked pathways, assess the possible interactions among environmental effects of the proposed project(s) and the environmental effects of past, present and future projects and activities.

(7) Determine the likelihood and significance of cumulative effects of the proposed project(s) on the VECs.

(8) Identify appropriate mitigation and monitoring measures.

Four pragmatic steps have been identified for delineating potential sources of the cumulative effects of a proposed project; they include (Klein and Kingsley, 1994): (1) identify and describe all relevant aspects of the project; (2) identify all other land uses or projects, existing and pending, that may relate to the project under review; (3) identify the relevant environmental systems or components that might be effected by the project; and (4) identify any other interactions which may be important. Selection criteria related to Step (2) include (Klein and Kingsley, 1994): (a) likelihood of the project occurring (formal approval can be considered a good indicator of this, but not the only measure); (b)temporal aspects, e.g., projects occurring sooner rather than later; (c) zone of influence, e.g., the proximity of the projects geographically, and the probability of both projects affecting the same environmental system; (d) spin-off effects, e.g., the potential of the project to have broad influence and lead to a wide range of effects or to lead to a number of associated projects; and (e) occurrence of related effects, e.g., if the effects of the other projects are similar to those of the project under review.

Table 2.1 displays 11 steps organized in accordance with three typical components of the EIA process (Council on Environmental Quality, 1997a). The 11 steps, while focused on CEA, are conceptually similar to traditional steps used within the EIA process. Accomplishment of these steps can be facilitated through the use of methodologies; such methods are addressed in Chapters 5 and 6 herein.

The 8 principles listed in Table 1.3 are specifically related to the CEA steps in Table 2.1 as follows: (1) principles 1 through 4 in Table 1.3 are related to Steps 1 through 4 in Table 2.1; (2) principles 5 and 8 in Table 1.3 are related to Steps 5 through 7 in Table 2.1; and (3) principles 6, 7, and 8 in Table 1.3 are related to Steps 8 through 11 in Table 2.1. In addition, it should be recognized that the 11 steps in Table 2.1 are not necessarily conducted in a linear fashion; in fact, steps 4 and 1 probably need to be addressed conjunctively. Also, iterations may be needed for the listed steps.

Further, and as shown in Table 2.2, the Cumulative Effects Assessment Working Group (1997) in Canada recently delineated typical CEA tasks within the context of the EIA process. These tasks are conceptually similar to the CEA steps developed by the CEQ and displayed in Table 2.1.

EXAMPLES OF PROCEDURAL APPLICATIONS

Three examples of specific procedural applications of CEA will be described. First, the U.S. Fish and Wildlife Service, a natural resources agency, has suggested that CEA should focus on process and long-term environmental management rather than specific methods used in a one-time study with no follow-on. The basic steps in their cause/effect process are (Vestal, et al., 1995): (1) scoping -- define the ecological situation in specific terms of individual problem statements and select one strategy

Table 2.1: Steps in CEA to be Addressed in Components of the EIA Proce
(Council on Environmental Quality, 1997a)

EIA Components	CEA Steps
Scoping	1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals.
	2. Establish the geographic scope for the analysis.
	3. Establish the time frame for the analysis.
	4. Identify other actions affecting the resources, ecosystems, and human communities of concern.
Describing the Affected Environment	5. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to changes and capacity to withstand stresses.
	6. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds.
	7. Develop a "baseline condition" for the resources, ecosystems, and human communities.
Determining the Environmental Consequences	8. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities.
	9. Determine the magnitude and significance of cumulative effects.
	10. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects.
	11. Monitor the cumulative effects of the selected alternative and adapt management.

Table 2.2: CEA Tasks Within the EIA Process (Cumulative Effects Assessment Working Group, 1997)

EIA Steps	CEA Tasks
1. Scoping	• Identify regional issues of concern • Select appropriate regional VECs • Identify spatial and temporal bounds • Identify other actions that mav affect the same VECs
2. Analysis of Effects	• Complete the collection of regional baseline data • Assess effects of all selected actions on VECs
3. Identification of Mitigation	• Recommend mitigation measures
4. Evaluation of Significance	• Evaluate the significance of residual effects • Compare results against thresholds or land use objectives and trends
5. Follow-up	• Recommend regional-wide monitoring

for each problem; (2) analysis -- investigate and document the problems and their causes in detail using the best available data and analytical tools and then set several goals; (3) interpretation -- develop and document options, estimate changes using mathematical models, and develop a plan; and (4) direction -- implement and incrementally improve the management plan and systematically evaluate, improve and update the problem statements, data, analytical tools, and mathematical models.

Application of CEA within the EIA process used in the national park system in Canada is shown in three nested scales in Figure 2.1: the individual project scale (project-EIA), the park scale (park-level CEA), and the regional scale (regional analysis) (Kalff, 1995). The nested scales and their related steps are self-explanatory and can be used to make the connection between regional analysis, park-level CEA, and project-EIA, and to provide advice on what project, activities, and policies should proceed, be mitigated/amended, postponed, or be stopped. Project-EIA should be conducted as projects are proposed for a park, while park-level CEA and regional analysis could be done less frequently; for example, every five years (Kalff, 1995).

Finally, Southerland, et al. (1997) have described the following 10-step process for addressing the cumulative effects of power generation and transmission in the State of Maryland in the United States:

Step 1. Identify the significant cumulative effects issues (resource-stress linkages) associated with power generation and transmission.

Step 2. Establish the geographic scope for the analysis.

Step 3. Establish the time frame for the analysis.

Step 4. Identify other (nonpower related) actions affecting the resources or ecosystems of concern.

Step 5. Characterize the baseline condition of resources or ecosystems of concern in terms of their capacity to withstand stresses.

Step 6. Characterize the stresses affecting these resources or ecosystems and their relation to regulatory thresholds (where available).

Step 7. Identify the important cause-and-effect relationships between human activities and resources or ecosystems.

Step 8. Determine the magnitude and significance of cumulative effects.

Step 9. Develop appropriate mitigation and enhancement measures for affected resources and ecosystems.

Step 10. Monitor and evaluate the cumulative effects of the power-related actions.

CUMULATIVE AIR QUALITY EFFECTS

An 8-step method for addressing cumulative effects on one environmental resource, has been proposed by Rumrill and Canter (1998). The method is a result of research consisting of: (1) a review of recent environmental impact statements (EISs) and environmental assessments (EAs)

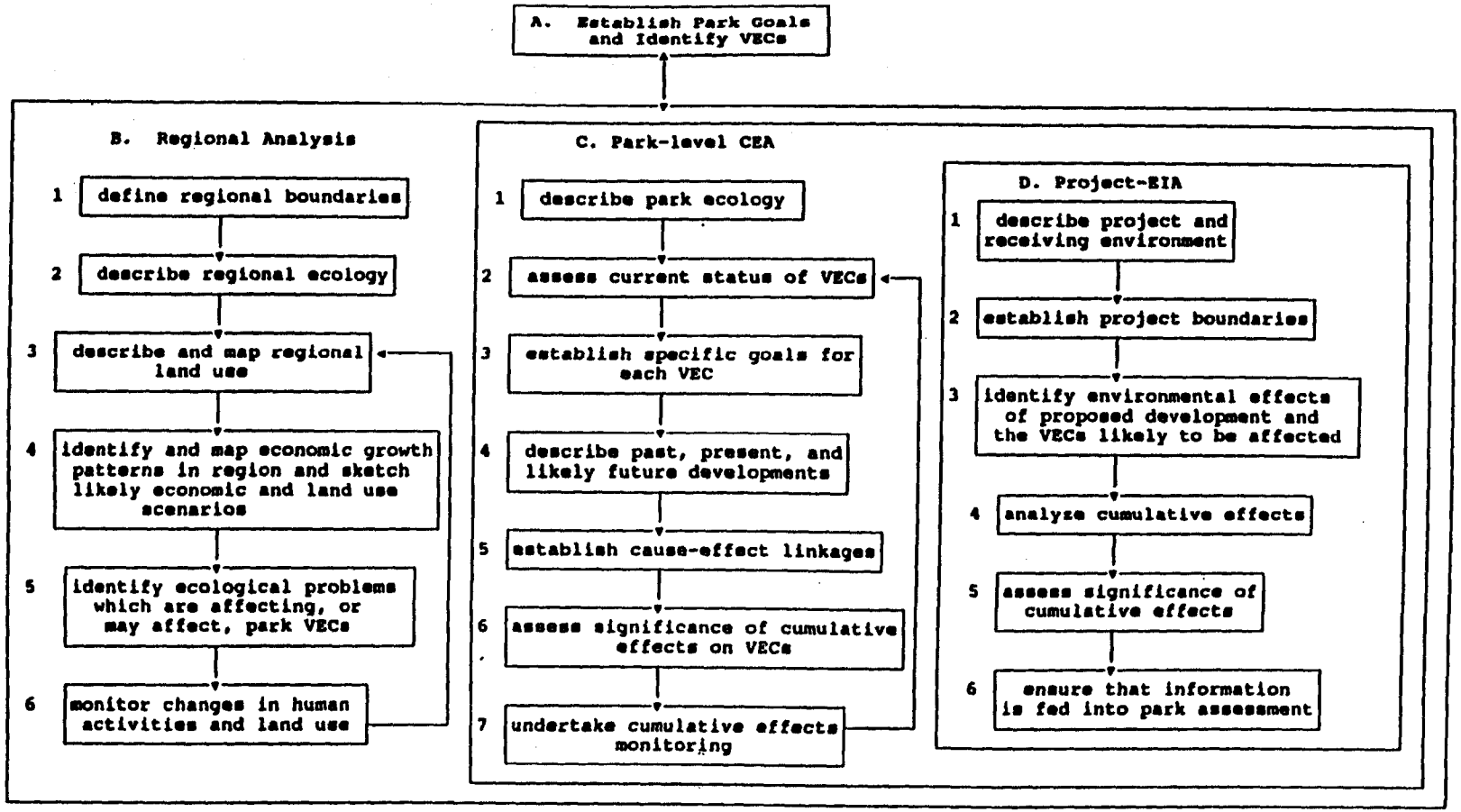

Figure 2.1: CEA Steps for Canadian National Parks (Kalff, 1995)

to identify and evaluate the techniques used to assess cumulative and air quality impacts (focused on a review of 27 EISs and EAs completed by the United States Air Force); (2) a review and analysis of approximately forty (40) federal and state court cases heard in the United States where rulings were made relevant to the legal interpretation of what actions are defined as reasonably foreseeable future actions (RFFAs); (3) a review of air quality impact quantification methods and selection of methods that are best suited to CEA; (4) the development of a conceptual approach for significance determination for cumulative air quality effects and associated opportunities for mitigation; and (5) method testing to demonstrate how the environmental planner can use the method to assess effects with varying degrees of accuracy and levels of detail depending on information availability and concern about air quality in the study area. The details relative to this research can be found in Rumrill (1998).

Table 2.3 presents the eight steps in the cumulative air quality effects assessment (CAQEA) method. The CEA process can be accomplished either as an integral part of the environmental impact assessment (EIA) process applied to a specific project; or, it can be accomplished as a separate study for a general area and timeframe and incorporated by reference and extracts into individual project assessments. The steps of the CAQEA method begin with the selection of a definition of cumulative effects to apply throughout the analysis. There are several definitions available as described in Chapter 1, and while each may be valid, the uniform employment of a single definition reduces the likelihood of inconsistencies in a specific CEA study.

Step 2, the determination of spatial and temporal boundaries, must include consideration of practical limitations such as time, funding, political influence, and the predictive capabilities of the models employed. A reasonable beginning to boundary selection is the spatial and temporal range of the predicted effects of the proposal originating the requirement of CEA. In this case, the boundaries could be based on the anticipated dispersion area for the emitted pollutants over a time period where those effects could be reasonably monitored or modeled. These boundaries can then be adjusted based on the additional, reasonably foreseeable, or connected, actions that are addressed with the original proposal as well as other factors related to information availability and the increasing uncertainty of predictions associated with considerations further into the future.

In Step 3, the future activities to evaluate are selected. The selection of the activities to evaluate firmly defines the context and extent, and thus influences the contextual significance, of the analysis. Accordingly, a procedure is included in Chapter 3 herein specifically for the delineation of appropriate future activities to include in a CEA.

Step 4, the determination of background ambient pollutant concentrations and related regulatory standards, establishes the baseline conditions against which the subsequent CEs are to be evaluated. This information should be obtained for each pollutant addressed in the evaluation.

The fifth step requires the development of an air emission inventory, relative to the pollutants of concern, for the identified activities within the temporal and spatial boundaries. This information can be obtained from such sources as emission inventory reports and state emission summary reports, and/or developed independently from available emission estimating procedures.

In Step 6, the assessor must determine the quantitative and qualitative change to the air quality resulting from the cumulative

Table 2.3: Steps in the CAQEA Method (Rumrill and Canter, 1998)

Step	Comments
1. Select definition of CE to be applied to the analysis.	CEQ definition is recommended.
2. Determine spatial and temporal boundaries.	Consider physical airshed and political regions (spatial) and forecasting capability limitations (temporal).
3. Determine past, present, and reasonably foreseeable future actions (RFFAs) to be included in the analysis.	See section of Chapter 3 addressing RFFAs.
4. Determine background ambient air pollutant concentrations and obtain applicable standards.	Regional air quality monitoring station data is recommended. Standards can include ambient air quality standards and emission standards.
5. Develop quantitative and qualitative emission data estimates for the actions determined in Step 3.	Develop an emission inventory for the project and other actions in the spatial and temporal boundaries.
6. Determine quantitative and qualitative change to background air quality (determined in Step 4) resulting from evaluated actions.	Emissions inventories and quantitative air quality modeling can be useful. See section of Chapter 9 summarizing three types of models.
7. Evaluate the CE significance in context with the air quality impacts of the action originally generating the NEPA requirement and incorporate that significance into the assessment.	Necessary to properly determine impact significance. See section of this paper which describes a scoring method for CE significance determination.
8. Include mitigation opportunities for CEs when discussing specific action impact mitigation.	Additional mitigation opportunities/options are available when other activities are considered. See section of Chapter 9 that highlights these opportunities.

influence of the evaluated activities. This can be done either through direct comparison of the pre-existing and resultant emission levels or through modeling techniques used to approximate changes to ambient concentrations. Regardless of which method is used, the assessor should include a discussion of the uncertainty in each of the predictive methods employed so as not to lend undue weight to the value of the forecasted results.

The seventh step is the determination of the cumulative significance resulting from the evaluated future proposal(s) within the context of the spatial and temporal timeframe of the analysis and the associated activities. Effects intensity ratings and a scoring matrix for combining various legal, political, and health considerations associated with effects significance are included herein. This provides the basis for a standardized significance determination system with results that can be incorporated into multiple future environmental analysis studies.

Determination of cumulative effects significance differs from that of project-level impact significance. In a CEA, multiple activities must be considered. The timing and location of these proposals can influence the spatial and temporal boundaries considered, and the resultant significance determinations. Whereas a project-level assessment considers the environmental consequences of a single action on its local surroundings, a CEA needs to address the long-term significance of the original proposal and other proposals connected either by proponent agency planning, geographic proximity, or affected resource. A CEA addresses not only the ability of the environment to assimilate the impacts of the original proposal, but also its influence on development sustainability.

Since there was no available method for addressing the significance of cumulative air quality effects, relevant air quality issues were considered, along with the assistance of a group of eight environmental professionals with experience in air quality and CEA issues, in the development of a list of factors for application to a systematic significance determination procedure. The result is a list of 18 factors (see Table 2.4) determined to be appropriate for consideration in air quality cumulative effect significance determinations (Rumrill, 1998). The factors were categorized into six functional groups; however, some issues overlap multiple categories. For example, the combination of sulfur dioxide and suspended particulate matter can result in a synergistic adverse health effect. Therefore, it could theoretically fall under two categories: secondary/indirect/synergistic effects, and health effects. Professional judgment must dictate where it is applied for each assessment.

As indicated in Table 2.4, only 6 of the 18 factors determined to be of relevance in a cumulative assessment of air quality are typically addressed in project-level assessments. Project specific assessments will typically address the change in emission level, but only based on the contribution of a single proposal. Comparison to permit rules or limitations is also common; however, the study area trends toward compliance may not be addressed. Under the ambient concentration category, it is common to find discussions relating the proposal contributions to ambient levels and comparisons to standards. Also, project-level impact studies usually include public concern relative to air quality issues. The remaining issues presented as being important to a cumulative analysis are unique to the holistic evaluation goals of a human community, regional, or larger level analysis.

Once the factors in Table 2.4 have been reviewed as to their relevance for a specific CEA study, the next step is to actually apply them to the available air quality cumulative effects data. Importance

Table 2.4: Significance Determination Factors in the CAQEA Method

Pollutant Emissions
- % change in total area emission level of a pollutant
- timing, duration, and rate of emission level change*
- comparison of emission rates to emission permit or rule limitations* (% of sources not meeting requirements)

Ambient Air Quality Standards
- change in ambient concentration*
- timing, duration, and rate of ambient concentration change*
- violation of standards* (federal, state, local)
- influence on air pollution episodes
- influence on current area classification (attainment/non-attainment, maintenance area, prevention of significant deterioration (PSD) area)

Public Perception
- level of concern expressed by public over air quality issues*

Secondary/Indirect/Synergistic Effects
- influence on photochemical pollution level (PPL) potential
- influence on VOC/NO_x ratio
- influence on stratospheric ozone
- influence on global warming
- spatial (transboundary) transport of pollutants (national, global)
- influence on SO_2 & NO_x contribution to acid deposition potential

Human Health
- level of carcinogenic effect
- level of non-carcinogenic effect

Mitigation
- timing/focus of mitigation efforts vs. timing/focus of effects

*Similar to factors typically addressed in project-level EIA.

Note: Sensitive receptors are not listed as a category for inclusion; however, they are addressed. A regional level analysis will typically always have some mix of sensitive receptors (e.g. children, hospital patients, elderly, specific crops, terrestrial vegetation, valued structures or monuments, etc.) that could be affected. Direct consideration of sensitive receptors should be accomplished at the individual project assessment level where local plume concentrations and dimensions can be evaluated. At this level of analysis, consideration of sensitive receptors is included within the considerations of ambient air quality standards and secondary/indirect/synergistic effects.

weights should be assigned to each of the significance factors corresponding to the expert opinion-derived level of importance. Table 2.5 presents a scoring matrix with the recommended importance weights. The factors are assigned high, medium, and low importance scores usable for generic application at a local or regional scale; however, for specific applications (e.g., global analysis) the user can make alterations in the listed importance weightings.

Air quality effects resulting from the combination of all activities in the study area should then be rated as to the intensity of their influence on each factor. Note that some factors may need to be rated for individual pollutants or spatial boundary conditions (e.g., local, regional, national, etc.) to complete the analysis. Recommendations corresponding to three levels of impact intensity for the 18 factors are presented in Table 2.6. Next, the intensity rating for each factor is multiplied by the assigned importance weight. The results are placed in the "Weighted Effect" column in Table 2.5. Once all "weighted effects" are determined, they are added to yield a single score. The possible range of scores for a single pollutant is from 0 to 108. Based on this range, the significance of the corresponding cumulative air quality effect can be ascertained. The available range of values could be divided into the following groupings:

0 - 35 (low significance or nonsignificant)

36 - 72 (moderate significance)

73 - 108 (high significance)

Assessments resulting in low "weighted effect" scores (0 to 35) can easily be termed as nonsignificant. Where a score is determined to be in the high range (73 to 108), the assessment should clearly state that a significant adverse effect is predicted. However, where assessments result in moderate range scores (36 to 72), professional judgment must be used in applying specific labels. Combined consideration of the cumulative effect with the direct effects related to the proposal originally generating the requirement for the NEPA process may sway the decision. Additionally, the level of uncertainty in the predictive techniques should be considered in determining the score's interpretation.

Beneficial effects are rated in the scoring matrix in combination with the "no effect" condition to eliminate the potential for a beneficial effect to mathematically "cancel" an adverse effect (Table 2.5). Beneficial effects should, however, be considered as a complementary issue. Also, severely adverse effects may be muted by the limitations of the scoring system. To ensure that the contributions of beneficial and severely adverse effects are not masked by the analysis matrix, a short discussion of these effects should be included along with the composite quantitative rating. If several composite ratings are developed due to multiple boundary conditions, or several pollutant analyses, each should be presented and discussed.

Scientific uncertainty is associated with multiple activities in the CEA process. When assessing air quality effects, uncertainty can be found in the estimation techniques used to determine source emission strength, and models for predicting dispersion characteristics and ambient concentrations. Potential error related to source emission estimates stems from the prediction of the actual future activity. For example, fugitive dust estimations are based on soil water content, construction vehicle use rates, meteorological conditions, and acreage estimates. Actual conditions can, and typically do, vary from the average data.

Table 2.5: Scoring Matrix for Air Quality Cumulative Effect Significance Determination

Factors	Factor Weighting (a) High importance = 3 Medium importance = 2 Low importance = 1	Cumulative Effect Intensity (b) Large Adverse = 3 Moderate Adverse = 2 Small Adverse = 1 No Adverse Effect or Beneficial Effect = 0	Weighted Effect (axb)
<u>Pollutant Emissions</u>			
% change in emission level	2		
timing, duration, and rate of change	2		
comparison to emission limitations (% noncompliance)	2		
<u>Ambient Air Quality Standards</u>			
change in ambient concentration	2		
timing, duration, and rate of change	2		
violation of standards	3		
influence on air pollution episodes	2		
influence on current area classification	2		
<u>Public Perception</u>			
level of public concern	3		
<u>Secondary/Indirect/Synergistic Effects</u>			
influence on PPL potential	2		
influence on VOC/NO_x ratio	2		
influence on stratospheric ozone	1		
influence on global warming	1		
spatial (transboundary) transport	2		
influence on acid deposition potential	2		
<u>Human Health</u>			
level of carcinogenic effect	2		
level of non-carcinogenic effect	2		
<u>Mitigation</u>			
timing/focus of mitigation vs. timing/focus of effects	2		
			Total =

Note: This matrix should be applied relative to each spatial boundary condition and pollutant addressed in the analysis.

Table 2.6: Impact Intensity Rating Recommendations

Factor	Cumulative Impact Intensity		
	High (3)	Moderate (2)	Low (1)
Pollutant Emissions - % change in emission level	10% or greater increase	5 - 9% increase	< 5% increase
- timing, duration, and rate of change	occurs early in study period, > 5 years duration, high rate of increase	occurs midway through study period, 1 - 5 years duration, moderate rate of increase	occurs late in study period, < 1 year duration, slow rate of increase
- comparison to emission limitations (% noncompliance)	10% or greater	5 - 9%	< 5%
Ambient Air Quality Standards - change in ambient concentration	> 5% increase	1 - 5% increase	< 1% increase
- timing, duration, and rate of change	occurs early in study period, > 5 years duration, high rate of increase	occurs midway through study period, 1 - 5 years duration, moderate rate of increase	occurs late in study period, < 1 year duration, slow rate of increase
- violation of standards	cause new violation	impairs plans to mitigate existing violation	small contribution to existing violation
- influence on air pollution episodes	new occurrence where none observed before or large increase in existing number of episodes	moderate increase in existing episode frequency or required level of response	small increase in existing episode frequency or required level of response
- influence on current area classification	exceeds classification based limits	classification based limits reached	limits future development
Public Perception - level of public concern	high level of concern	some concern	little concern
Secondary/Indirect/Synergistic Effects - influence on PPL potential	10% or greater increase in precursor emissions	5 - 9% increase in precursor emissions	< 5% increase in precursor emissions
- influence on VOC/NO_x ratio	10% or greater increase to limiting pollutant or change of limiting pollutant	5 - 9% increase to limiting pollutant	< 5% increase to limiting pollutant
- influence on stratospheric ozone	large increase in ODC emissions	moderate increase in ODC emissions	small increase in ODC emissions
- influence on global warming	large increase in precursor emissions	moderate increase in precursor emissions	small increase in precursor emissions
- spatial (transboundary) transport	large contribution to downwind area concentration	moderate contribution to downwind area concentration	small contribution to downwind area concentration
- influence on acid deposition potential	large increase in precursor emissions	moderate increase in precursor emissions	small increase in precursor emissions
Human Health - level of carcinogenic effect	known human carcinogen	probable human carcinogen	possible human carcinogen
- level of non-carcinogenic effect (dose response relationships, comparison to thresholds, synergisms, etc)	Air Toxics - concentration above MAAC (or TLV/1000) Others - high likelihood of adverse effect	Air Toxics - concentration at MAAC (or TLV/1000) Others - moderate likelihood of adverse effect	Air Toxics - measurable conc. below MAAC (or TLV/1000) Others - low but identifiable possibility of adverse effect
Mitigation - timing/focus of mitigation vs. timing/focus of effects	allows for long-term (>5 years) continuance of mitigable effect	allows for continuance of mitigable effect for 1 - 5 years	allows for continuance of mitigable effect for less than one year

ODC = Ozone Depleting Chemical, MAAC = Maximum Allowable Ambient Concentration, TLV = Threshold Limit Value

Inherent assumptions in the dispersion models introduce error as can mistakes in input data. Model validation or calibration techniques can be employed to minimize this source of uncertainty. Therefore, the recommended format for handling uncertainty in the CAQEA method is the preparation of an uncertainty report (the report can be included as an appendix in the impact study document). Once the uncertainties from all predictive techniques are combined, relative uncertainties can be determined and decisions regarding additional studies or activity modifications can then be made.

Finally, Step 8 in Table 2.3 addresses opportunities for cumulative effects mitigation. The intent of this step is to expand mitigation options beyond consideration of only the original proposal to encompass multiple future activities. This approach promotes improved cost effectiveness in the expenditure of limited mitigation resources.

SUMMARY COMPARISONS OF EIA AND CEA

The EIA process has typically focused on a project (the proposed action) and its resultant consequences (effects or impacts) on components of the biophysical and socio-economic environments. One useful perspective in CEA is to focus on affected environmental components or VECs and the "contributions" of multiple projects toward their resultant stress or effects. This perspective has been suggested by the examples of step-wise procedures included in this chapter. Figure 2.2 depicts these comparisons. Further, Table 2.7 displays comparative information on a single project-focused EIA and CEA arrayed against a series of eight topics. These comparisons represent a useful summary of how CEA can be incorporated within the EIA process.

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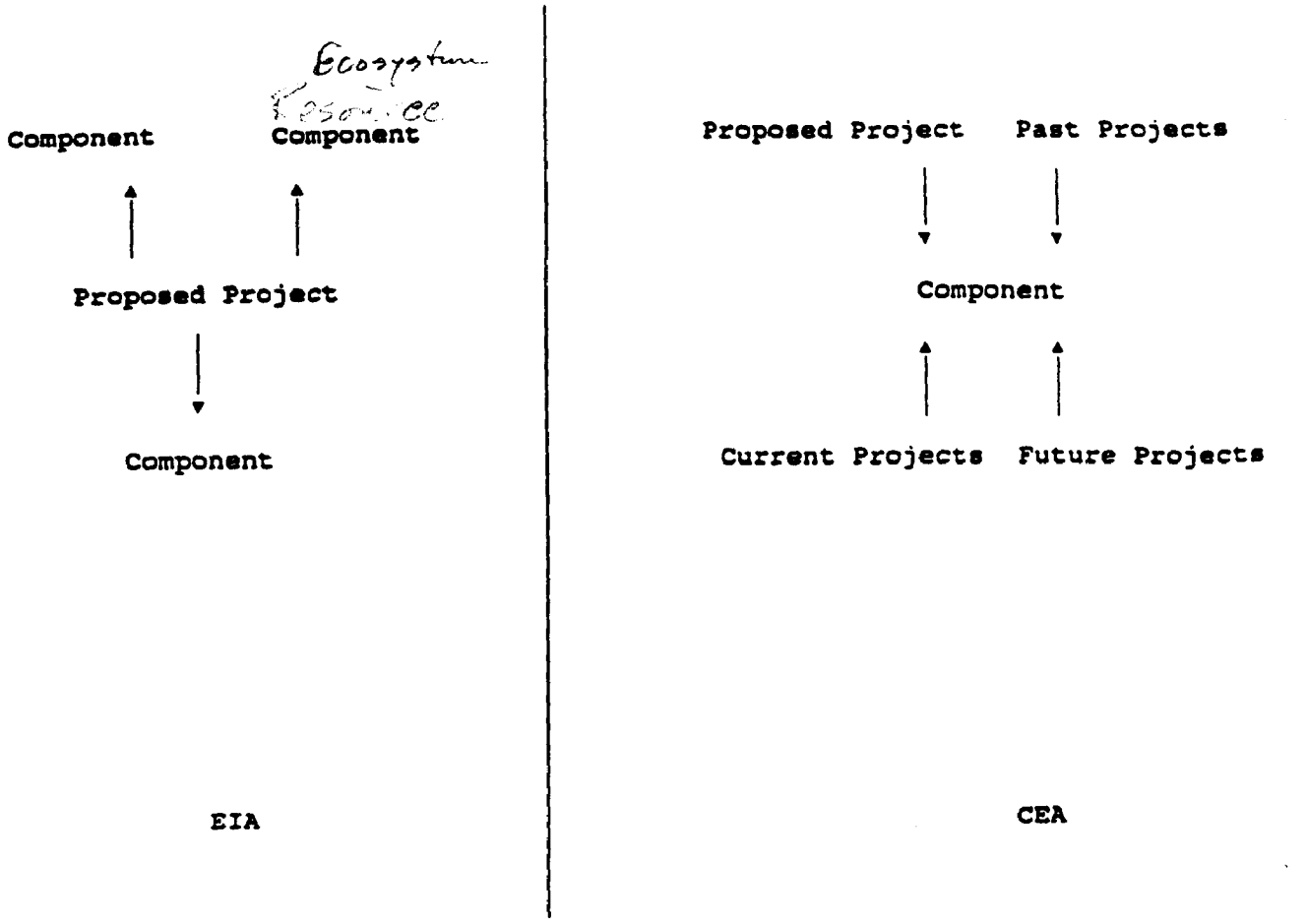

Notes: Component refers to various biophysical or socio-economic components of the environment; proposed project refers to the proposed action.

Figure 2.2: Comparisons of Focus of EIA Process Versus Focus of CEA within the EIA process (after Kalff, 1995)

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CHAPTER 3

SPECIAL ISSUES IN CEA

Planning a CEA study involves delineating appropriate spatial and temporal boundaries, identifying "reasonably foreseeable future actions" in the environs of the proposed action; establishing baseline conditions for affected resources, ecosystems, and human communities; and determining the significance of predicted cumulative effects. These special CEA issues are addressed in this chapter.

DELINEATING SPATIAL BOUNDARIES

Appropriate spatial and temporal boundaries in a CEA should be based on both "activity information" and "environmental information" (Irwin and Rodes, 1992). Activity information should involve consideration of the types and rates of release, movement, and transformation of materials and energy. Environmental information includes understanding ecological processes, such as bioaccumulation, that control these rates. It may also involve understanding the ranges of plants and animals. Cumulative effects on the socio-economic environment can encompass information needs related to human populations, economic and health indicators, and infrastructure requirements. It should be recognized that different spatial and temporal boundaries may well be appropriate for different types of cumulative effects.

The following factors should be considered in delineating spatial boundaries for a CEA conducted in conjunction with a proposed project (after Drouin and LeBlanc, 1994): (1) the size and nature of the project and its anticipated effects; (2) the availability of existing data and knowledge about the project and its environmental effects; (3) the feasibility of collecting new data and knowledge; (4) the size, nature, and environmental effects of past, existing, and future projects and activities in the area; (5) the characteristics and sensitivity of the receiving environment (extent and degree of existing stress); (6) relevant ecological boundaries, including watersheds, sub-watersheds, and major landscape features; and (7) relevant jurisdictional boundaries. Some "rules-of-thumb" related to establishing the spatial boundaries for a CEA study are shown in Table 3.1 (Cumulative Effects Assessment Working Group, 1997).

Even though the spatial boundary considerations are straightforward, there are some difficulties associated with defining such boundaries, examples include (Burris and Canter, 1997b): (1) the lack of pertinent information; (2) need for different boundaries for different effects/resource areas; (3) drawing the line on where effects stop and who settles disputes; (4) incomplete understanding of linkages that may expand or confine the area; (5) lack of CEA study funds, time to conduct study, and incomplete knowledge of the problem; and (6) determining a balance between the environmental components, boundaries, and jurisdictions of relevant controlling bodies.

DELINEATING TEMPORAL BOUNDARIES

Delineating the temporal boundaries for a CEA study involves determining how far in the past to consider in establishing the historical

Table 3.1: Rules-of-Thumb for Consideration in Establishing Spatial Boundaries (Cumulative Effects Assessment Working Group, 1997)

- Establish a local study area to separate out the obvious, easily understood and often mitigable effects.
- Establish a regional study area that includes possible interactions with other actions. Consider the interests of other stakeholders.
- Use of several boundaries (e.g., one for each environmental component) is often preferable to one boundary.
- Boundaries should expand sufficiently to address the cause-effect relationships between actions and VECs.
- Characterize the abundance and distribution of VECs at a local, regional, or larger scale if necessary (e.g., for very rare species), and ensure that the boundaries take this into account.
- Determine if geographic constraints may limit cumulative effects within a relatively confined area near the action.
- Characterize the nature of pathways that describe the cause-effect relationships to establish a "line-of-inquiry" (e.g., effluent from a pulp mill to contaminants in a river to tainting of fish flesh and finally to human consumption).
- Determine where these effects become insignificant (e.g., effect within natural variability, below regulated thresholds); boundaries should end upon reaching the point at which cumulative effects become insignificant.
- Estimate the reversibility of the effects (i.e., time required for recovery).
- Be prepared to adjust the boundaries during the assessment process if new information suggests that this is warranted, and defend any such changes.

boundary, and how far in the future would be relevant in establishing the time period encompassing reasonably foreseeable future actions. Figure 3.1 depicts a time line with the boundaries displayed. Unfortunately, no precise guidelines have been established for determining how far to extend the past or future. Specific temporal boundaries will be dependent on the type of project, its location, and historical and planned actions in the vicinity. Examples of pragmatic questions, issues and information to consider in selecting temporal boundaries include:

(1) Does the project proponent have a written policy regarding temporal boundary delineations?

(2) In the absence of a written policy, what has been the practice of the proponent in establishing temporal boundaries for other projects?

(3) Does the proponent require an economic evaluation (e.g., a cost-benefit analysis) of the project? If so, what time period is required (e.g., 25 years into the future)?

(4) What historical monitoring data or information exists for potentially affected resources, ecosystems, and human communities? Can such data or information be used to select indicators for present and future conditions? Could information from historical aerial photography in the study area be utilized to describe changes in land uses over time, particularly with regard to the consequences of past actions?

(5) Do any regional development or general environmental management (conservation) plans exist for or incorporate portions of the study area? If historical planning documents exist, have they been modified over time? What types of planning documents exist for future actions or management strategies? Do any specific resource or ecosystem management plans exist for the study area?

(6) What rates of change have occurred in the past regarding pertinent resources, ecosystems, and human communities? What rates are currently being experienced, and what changes in the rates, if any, are expected in the short (2 to 5 years) and longer (5 to 25 years) time frames?

(7) Have governmental policies regarding growth and development activities changed over time? Are policy changes or new management strategies expected in the future, and what are the implications of such changes and strategies?

(8) Are there any special considerations related to historical or anticipated changes in environmental quality standards for the potentially affected resources and/or ecosystems? What is the successional stage of relevant ecosystems, and the expected time periods for subsequent stages?

(9) What is the planned lifetime of the proposed action? For example, if the extraction of non-renewable resources is proposed, what is the time period for complete depletion? If renewable resources are to be used, are there planned programs for restoration (e.g., tree plantings in areas of timber harvesting for wood products)? Will a proposed chemical manufacturing plant be obsolete after x years due to changes in manufacturing technologies? Will the capacity of a waste

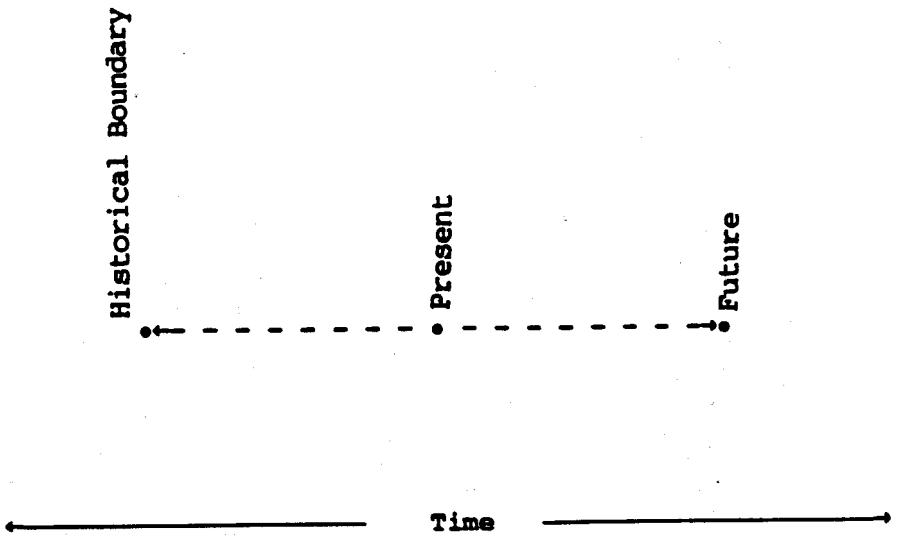

Figure 3.1: Terminology for Delineation of Temporal Boundaries

disposal site be used up after x years, and are there longer term land reclamation efforts which will be implemented?

(10) If cumulative effects are associated with land use changes and/or the emissions of air and/or water pollutants, are historical data available on such changes/emissions for past and present actions? Can information of this type be procured for future years?

(11) Are there any unique characteristics of pollutant emissions from the proposed action and/or past, present, and reasonably foreseeable future actions that should be considered in establishing the temporal boundaries? Examples include the half-life of the environmental biodegradability of pollutants, and long term transport concerns in the subsurface environment.

To summarize, some options for consideration in establishing past and future temporal boundaries for a CEA study are shown in Table 3.2 (Cumulative Effects Assessment Working Group, 1997). However, difficulties can occur in delineating the temporal boundaries for a CEA study; they include (Burris and Canter, 1997b): (1) defining where "short-term" ends and "long-term" begins; (2) determining what constitutes a reasonably foreseeable future action (a term used in the USA), especially for nonfederal proponents; (3) correlating old and current data for comparison (past data may be nonexistent, scarce, incomplete, or inaccurate); (4) possible absence of fundamental scientific and historical data; (5) determining a proper balance between the short-term interests (10-20 years) of planning authorities and long-term sustainability interests; (6) recognizing that appropriate spatial boundaries may shift over time; (7) insufficient time and funding for the CEA; and (8) uncertainty and lack of confidence in predictions.

Finally, even though many factors or issues related to defining the historical boundary of a study can be identified, it should be noted that the effects of past and present actions, irrespective of how far the historical time period is extended, can be reflected in the careful documentation of baseline environmental conditions (Kreske, 1996).

DETERMINING REASONABLY FORESEEABLE FUTURE ACTIONS

Adequate consideration of cumulative effects within the EIA process in the United States must involve an analysis of the proposed action in view of past, present, and reasonably foreseeable future actions (RFFAs). One key difficulty in this analysis is the determination of what activities should be considered as RFFAs. For over two decades, the answer to the question -- when does a contemplated action become "reasonably foreseeable?" -- has been argued in the United States courts. In fact, at least 40 court cases have involved cumulative effects, and many of them hinged on the determination of RFFAs. A number of independent and overlapping issues regarding RFFAs were addressed in the cases; for example, is there a need for formal proposals to delineate RFFAs versus the existence of speculative actions in informal proposals. Table 3.3 summarizes 15 such issues identified via a systematic review of the court cases (Rumrill and Canter, 1997). It should be noted that although the cases were from the United States, the general issues are applicable within many EIA systems.

Based on the issues addressed in the reviewed cases, and with the precondition that when the courts contradict, a conservative approach

Table 3.2: Considerations in Establishing the Temporal Boundaries for a CEA Study (Cumulative Effects Assessment Working Group, 1997)

Options for establishing the past boundary

Each of the following options progress further back in time:

- when impacts associated with the proposed project first occur;
- existing conditions;
- the time at which a certain land use designation was made (e.g., lease of crown land for the project, establishment of a park);
- the point in time at which effects similar to those of concern first occurred; or
- a past point in time representative of pre-disturbance conditions (i.e., the "historical baseline"), especially if the assessment includes determining to what degree later actions have affected the environment.

Options for establishing the future boundary

Each of the following points occur further ahead in time. Each later one better reflects the true effects of the project; however, assessment becomes more difficult to quantify if the time periods are very long (e.g., >30-50 years).

- end of operational life of project;
- after project abandonment and reclamation; or
- after recovery of VECs to pre-disturbance conditions (this should also consider the variability of natural cycles of change in ecosystems).

Table 3.3: Legal Issue Linkages to 8-Activity Method for Determining RFFAs (Rumrill and Canter, 1997)

Issue Addressed	Activity Affected	Comments
Only formal proposals are required to be considered as RFFAs	2	
Informal proposals beyond speculation are to be considered as RFFAs	3	
Remote or speculative informal proposals are not required to be considered as RFFAs	3,7	
Speculative effects are not required to be included after scoping process determines significant/speculative issues	7	
Future actions that (1) are a direct consequence of the current action and (2) where consideration could alter the nature of the project or its effects are to be considered as RFFAs	3,4,7	
Reasonable amount of forecasting is required	3	
Future actions directly tied to an overall goal are RFFAs	6	
Lack of independent utility or demonstration as a logical part in a chain requires related actions to be evaluated together	4	
Actions having independent utility are not required to be evaluated together	N/A	Does not support conservative approach
Geographic connections require actions to be evaluated together	1,3	
Geographic connections do not to require actions to be evaluated together	N/A	Does not support conservative approach
Other future actions within an agency undergoing the same level of review must be evaluated with the proposal	5	
Common natural resource threat or commitment or environmental effect connections require actions to be evaluated together	4	
Planning document related actions supporting defined goals are connected and are to be considered as RFFAs	6	
Plans that manage actions but do not promote their occurrence through the association of a goal are not required to be considered as connected or RFFAs	6	

Note: Activity 8 was not developed from court case review, however, proper documentation is central to the EIA and CEA processes. The identified steps are in Figure 3.2.

dictates that an action should be included, evaluation of future activities with respect to the following eight activities should minimize court challenges and public opposition on the basis of failure to include future actions in a CEA (the eight activities are displayed in Figure 3.2):

Activity 1: Determine reasonable temporal and spatial boundaries with respect to the availability of information, the realm of influence or control exerted by the subject agency, and the nature of the environmental impacts of the original project.

Activity 2: Within those boundaries, if the agency has additional formal proposals, approved or pending approval, relating to the accomplishment of any agency goal or objective, include them as RFFAs.

Activity 3: Conduct forecasting to determine possible, plausible, conceivable, and probable future activities" both internal and external to the subject agency that fall within the temporal and spatial boundaries established in Activity 1.

Activity 4: Evaluate the list from Activity 3 to determine possible connectedness to the original proposal. Consider: (a) geographic relationships; (b) common resources or environmental media impacted; and (c) causal links or catalytic effects, between the original and forecasted activities. If connections can be determined, consider those activities as RFFAs.

Activity 5: Again evaluating the list of proposals from Activity 3, determine if "significant amounts" of effort, resources, time, and/or money have been invested into the future activities. If so, consider the activities as RFFAs.

Activity 6: Within the area of concern, determine the existence of any planning documents, such as city or regional development plans, historic preservation plans, district plans, or environmental use plans, that relate future activities and the original proposal through a common goal or objective. If such relationships can be determined, consider the related future activities as RFFAs.

Activity 7: Evaluate the significance of each activity thus far categorized as reasonably foreseeable. Include consideration of: (a) whether or not obtaining useful information, or relevant prediction models, related to the environmental impacts of the activity is possible at this point in time; and (b) whether or not the information obtained will have any impact on the original project alternative evaluation and selection. If RFFAs are determined to be "insignificant" or impossible to evaluate at this time, exclude them from the list. The remaining RFFAs should be included in the CEA for the original project.

Activity 8: Document the evaluation of RFFAs and include that documentation in the final impact study report.

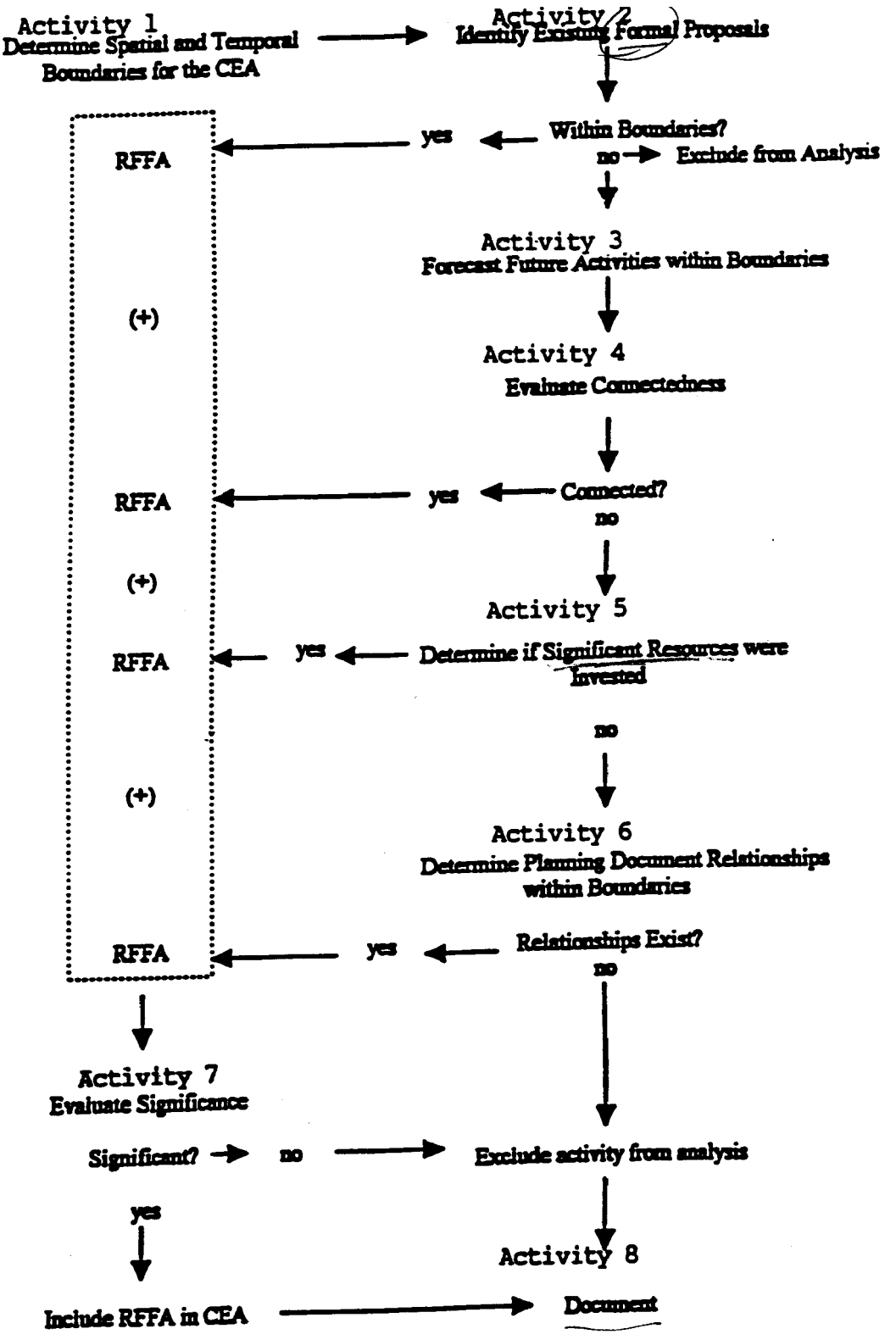

Figure 3.2: Decision Flowchart for Determining RFFAs (Rumrill and Canter, 1997)

Following these eight activities through the decision process illustrated in Figure 3.2 will ensure that most, if not all, relevant projects are included. It will demonstrate to the decision makers, regulators, and if necessary, the courts, that a concerted effort was made to comply with the spirit of the legislation and provide the pertinent information needed to make responsible decisions with respect to the protection of the environment.

While the basis for the recommended eight-activity Conservative Determination Method is a review of relevant issues from U.S. court cases, it is not intended that its application be restricted to the United States. The spirit and intent of NEPA is similar to that of environmental provisions of other nations in that all intend to provide decision makers with more complete and relevant information as to the environmental impacts of their actions. Several nations have recognized the importance of the assessment of cumulative effects. Careful consideration of the issues presented in this analysis will further refine the scoping process in CEA regardless of the regulatory framework in which the assessor operates.

Once future projects are identified based on the eight activities, the pragmatic issue turns to how they should be addressed in a CEA. One suggestion is that a typical "impact footprint" for each future project may be used in addressing the cumulative effects of "reasonable foreseeable future actions" (Kreske, 1996).

The output from identifying relevant past, present, and RFFAs in a CEA should be summarized in a tabular format as well as a map. Table 3.4 illustrates such a display associated with addressing the cumulative effects on resources, ecosystems, and human communities of concern for the Castle Mountain Mining Project of the U.S. Bureau of Land Management (U.S. Bureau of Land Management, 1990). Table 3.4 groups the activities by category, status, cumulative effects issues, and spatial boundary (location). Appropriate temporal boundaries are not displayed; however, they could be easily added by dividing the proposed activities into time periods. The summary approach shown in Table 3.4 is a useful way of organizing information.

ESTABLISHING BASELINE CONDITIONS

Step 7 in the Council on Environmental Quality list of 11 steps (shown in Table 2.1) for CEA requires that the "baseline condition" be described for the potentially affected resources ecosystems, and human communities (Council on Environmental Quality, 1997). Baseline in this case does not mean "existing condition" nor is it the same as "describing the affected environment." Baseline condition is perceived to denote the condition of a resource, ecosystem, or human community prior to its degradation by society's activities. Accordingly, it is primarily associated with the characteristics of potentially affected resources and ecosystems in their "pristine state."

From a conceptual standpoint, baseline conditions would be necessary in establishing current degradation to resources and ecosystems from the past actions of society. However, the fundamental dilemma in defining a baseline condition is related to the availability of historical information and trends data. Considerable debate on this issue is currently on-going in the United States. From a pragmatic standpoint, it may be necessary to identify current-day "pristine resources and ecosystems" and extrapolate this information to the study area for a CEA.

Table 3.4: Other Activities (existing and proposed) That May Cumulative Affect Resources of Concern for the Castle Mountain Mining Project (U.S. Bureau of Land Management, 1990)

Description/Responsible Agency	Status	Anticipated Environmental Issues That Could Be Cumulative	Primary Impact Location
Utilities/Services			
1 AT&T Communication cable upgrading (BLMN)	E,P	4,1	IV
2 PacBell microwave sites (BLMN)	E,P	4,1	IV
3 Bio Gen power plant (SBC)	E	2	IV
4 Additional utility lines (1-15 corridor) (BLMN)	P	4,4	IV
5 Whiskey Pete's airstrip/waterline (BLMN)	P	4	IV
6 Solid waste landfill (UP Tracks near state line) (BLMN)	P	4,12	IV
7 Waste water ponds (Ivanpah Lake) (BLMN)	E	4,9	IV
8 Nipton waste site (BLMN)	P	4,9	IV
9 LA-Las Vegas bullet train (BLMN)	P	4,9,10	IV
Commercial and Residential			
10 Nipton land exchange (BLMN)	P	4,6,12	IV
11 Scattered residential units (BLMN)	E,P	--	LV
Recreation			
12 Ivanpah Lake landsailing (BLMN)	E	4,5,10	IV
13 Barstow to Vegas ORV race (BLMN)	E	4,5,10	IV
14 East Mojave Heritage Trail use (BLMN)	E	4,5,10	IV,LV,PV
15 Mojave Road use (BLMN)	E	4,5,10	IV,LV,PV
16 Clark Country Road A68P use (BLMS,CC)	E	4,5,10	PV
Mining			
17 Proposed Action/Alternative - precious metals (BLMN)	P	3,4,5,8,9	LV
18 Colosseum Mine - precious metals (BLMN)	E	3,4,5,8,9	IV
19 Caltrans borrow pits - aggregates (BLMN)	E	4,5	IV
20 Morning Star Mine - precious metals (BLMN)	E	3,4,5,8,9	IV
21 Vanderbilt - precious metals mill site (BLMN)	E	3,4,5,8,9	IV
22 Golden Quail Mine - precious metals (BLMN)	E	3,4,5,8,9	LV
23 Hart District Clay Pits (BLMN)	E	4,9	LV
24 Mountain Pass Mine - rare earth materials (BLMN)	E	3,4,5,8,9	IV
25 Exploratory activities (BLMN, BLMS)	E,P	4,5,9	LV,PV
Grazing			
26 Grazing leases (BLMN, BLMS)	E	4,5	IV,V,PV
Source of Information BLMN: BLM Needles BLMS: BLM Stateline SBC: San Bernardino County. Planning Department CC: Clark County. Planning Department	Status E: Existing P: Proposed	Issues of the Project 1 Earth 2 Air 3 Water 4 Wildlife 5 Vegetation 6 Transportation 7 Public Service/Utilities 8 Health/Safety 9 Visual Resources 10 Recreation 11 Cultural Resources 12 Land Use	Location PV: Pirute Valley IV: Ivanpah Valley LV: Lanfair Valley

DETERMINING THE SIGNIFICANCE OF CUMULATIVE EFFECTS

Significance determinations for cumulative effects can be based on criteria similar to those used for project-level impacts as well as unique considerations associated with cumulative effects. Canter and Canty (1993) suggested a sequenced approach for project-level impacts based upon the review of significance definitions in the EIA laws, regulations, and/or guidelines of numerous countries. The sequenced approach for cumulative effects can be achieved by applying the following series of questions in the order shown (after Canter and Canty, 1993):

(1) Does the proposed project, plan, program, and/or policy cause cumulative effects that exceed the definition of significant cumulative effects as contained in pertinent laws, regulations or executive orders?

(2) Is the project, plan or program located in a protected habitat or land-use zone, or within an exclusionary zone relative to land usage? Is the environmental resource to be affected a significant resource? Will cumulative effects be of concern relative to the resource?

(3) Is the proposed project, plan, program and/or policy, as well as the associated cumulative effects, expected to be in compliance with pertinent environmental laws, regulations, policies, and/or executive orders?

(4) What is the anticipated percentage change in pertinent environmental factors or resources from the proposed project, plan, or program, and from cumulative effects, and will the changes be within the normal variability of the factors or resources? What is the sensitivity of the environment to the anticipated changes; or is the environment susceptible or resilient to changes? Will the carrying capacity of the resource be exceeded?

(5) Are there sensitive human, living, or inanimate receptors to the environmental stresses from the proposed project, plan, program, and/or policy, and from cumulative effects?

(6) Can the anticipated negative cumulative effects be mitigated in a cost-effective and timely manner?

(7) What is the professional judgment of experts in the pertinent substantive areas, such as water quality, ecology, planning, landscape architecture, geography, and archaeology?

(8) Are there public concerns due to the cumulative effects of the proposed project, plan, and/or program, when coupled with other past, present, and reasonably foreseeable future actions, in the study area?

Two additional specific questions which could be considered in determining the significance of cumulative effects are:

(1) Are the cumulative effects incompatible with the principles of environmentally sustainable development (e.g., governmental policies regarding conservation of renewable resources and/or depletion of nonrenewable resources)?

(2) Are there differences in the development and environmental protection/conservation policies of governmental agencies both within and between potentially affected sovereign countries? (This may be a significant concern when addressing transboundary cumulative effects.)

A fundamental issue in CEA is related to when cumulative changes may cause an environmental system threshold to be exceeded. In this context, thresholds refer to the point at which added system perturbations, no matter how small, will result in major system deterioration or collapse (Contant and Wiggins, 1993). A threshold value can be either a maximum or minimum number, or a related qualitative measure, which, if exceeded or not met, causes the predicted effect or resource use, to take on new importance (Witmer, et al., 1987). Thresholds are related to the carrying capacity of the relevant biophysical or socio-economic systems. The concept of carrying capacity was developed from biological sciences such as range and game management. Carrying capacity can be defined as the ability of biophysical or socio-economic (socio-cultural) systems to absorb the effects of development changes or human population growth without associated significant degradation or breakdown. Measurement of carrying capacity, and hence the determination of thresholds, can be complicated by natural system variations and compensatory response, technological innovations, and changing societal expectations and goals (Kalff, 1995).

Limits of acceptable change (LAC) refers to the change in environmental components that human societies are prepared to tolerate as custodians of the environment (Wight, 1994). This concept can be useful in dealing with socio-economic components and in incorporating sustainable development considerations into CEA.

Some other factors to consider in establishing the significance of cumulative effects are (Cumulative Effects Assessment Working Group, 1997): size of study area; incremental contribution of effects from project under review; relative contribution of effects of other actions; relative rarity of species; significance of local effects; magnitude of change relative to natural "background" variability; and creation of induced actions.

Finally, even though thresholds and carrying capacity are conceptually appropriate as factors to consider in significance determinations, their quantification remains problematic. For example, Ziemer (1994) has indicated that the problem of applying the concepts of cumulative effects and thresholds to ecological systems lies in the difficulty in understanding the complex interactions between the components of such ecosystems.

SUMMARY

This chapter has addressed five unique issues in conjunction with planning and conducting a CEA within a project-level environmental impact assessment or a strategic environmental assessment. The primary point of this chapter is that there are pragmatic considerations and approaches which can be applied for delineating spatial and temporal boundaries, identifying RFFAs, establishing baseline conditions, and determining the significance of predicted cumulative effects.

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CHAPTER 4

SCOPING FOR CUMULATIVE EFFECTS

In the late 1970s, the Council on Environmental Quality (CEQ) in the United States issued regulations for the environmental impact assessment (EIA) process initiated by the National Environmental Policy Act (NEPA). These regulations were to be focused on a more stream-lined approach in the preparation of environmental impact statements (EISs). A central feature of these regulations, which went into effect in July, 1979, was the concept of scoping. Scoping is targeted to identifying key impacts and issues; thus, it is focused on more directed studies by selection and attention to key impacts and issues of concern, including cumulative effects. In this regard, scoping for cumulative effects is not considered as separate from scoping for direct and indirect effects (impacts); rather, it is seen as integral to the overall scoping process.

Scoping is the first step of the EIA process where an impact study manager can be successful at making the EIA process cost less, count for more in decision making, and ensure that the public participates throughout the process. Key concerns related to possible cumulative effects can be identified during the scoping process. However, if scoping is treated as a public relations exercise or a legal requirement to be completed, it is likely the manager does not see scoping as an important analytical phase of EIA. This will likely result in an undisciplined, unstructured study that will cost more time and money than is necessary.

Based upon these perspectives, the topics to be addressed herein include pertinent definitions and components, federal agency involvement in scoping, general planning considerations for a scoping program, and the use of an analytical process for identifying and selecting key impacts (including cumulative effects) and issues from broader lists generated via multiple meetings, contacts, and information gathering efforts. Based upon these topics, key lessons related to the analytical aspects of scoping are delineated in the final section.

DEFINITIONS AND COMPONENTS

The term "scoping" refers to an early and open process for determining the "scope" of issues to be addressed and for identifying the significant issues related to a proposed action (Council on Environmental Quality, 1978). The term scope, which is defined in paragraph 1508.25 of the CEQ regulations, is summarized in Table 4.1 (Council on Environmental Quality, 1978). As can be seen, both "cumulative actions" and "cumulative impacts" (effects) are mentioned in the definition of the scope of the study. These issues need to be considered when a proponent agency determines the "scope" of the impact study.

The specific objectives of the scoping process have been identified as follows (Council on Environmental Quality, 1981 and 1986): (1) to identify the affected public and agency concerns; (2)to facilitate an efficient EIS preparation process, through assembling the cooperating agencies, assigning EIS writing tasks, ascertaining all the related permits and reviews that must be scheduled concurrently, and setting time or page limits; (3) to define the issues and alternatives that will be examined in detail in the EIS while simultaneously devoting less attention and time to issues which cause no concern; and (4) to save time in the

Table 4.1: Definition of Scope as Related to EISs (after Council on Environmental Quality, 1978)

Scope consists of the range of actions, alternatives, and impacts to be considered in an EIS. The scope of an individual statement may depend on its relationships to other statements. To determine the scope of EISs, agencies shall consider three types of actions, three types of alternatives, and three types of impacts. They include:

(a) Actions (other than unconnected single actions) which may be:

(1) Connected actions, which means that they are closely related and therefore should be discussed in the same impact statement. Actions are connected if they automatically trigger other actions which may require EISs; cannot or will not proceed unless other actions are taken previously or simultaneously; or are interdependent parts of a larger action and depend on the larger action for their justification.

(2) Cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should, therefore, be discussed in the same impact statement.

(3) Similar actions, which when viewed with other reasonably foreseeable or proposed agency actions, have similarities that provide a basis for evaluating their environmental consequences together, such as common timing or geography. An agency may wish to analyze these actions in the same impact statement. It should do so when the best way to assess adequately the combined impacts of similar actions or reasonable alternatives to such actions is to treat them in a single impact statement.

(b) Alternatives, which include: (1) the no-action alternative; (2) other reasonable courses of actions; and (3) mitigation measures (not in the proposed action).

(c) Impacts, which may be: (1) direct; (2) indirect; and (3) cumulative.

overall process by helping to ensure that draft statements adequately address relevant issues, reducing the possibility that new comments will cause a statement to be rewritten or supplemented. Objective (3) focuses on the need to systematically consider and prioritize issues generated during individual contacts and meetings. Included in objective (3) would be cumulative actions and cumulative impacts. Scoping can also be used as a conflict resolution tool if proponent agencies are willing to alter their proposals as a result of scoping (Council on Environmental Quality, 1981 and 1986).

Table 4.2 contains a summary of paragraph 1501.7 of the CEQ regulations regarding various components of the scoping process (Council on Environmental Quality, 1978). While a key component of scoping is public involvement, the analytical nature of the exercise should not be lost. In fact, the first contact between proponents of a proposal and the public may occur during the scoping process (Council on Environmental Quality, 1981 and 1986), thus it represents the initial opportunity for public participation in the EIA process. Additional public participation opportunities include the provision of information on related studies that can limit or expand the spatial and/or temporal boundaries of the study area (these are particularly important facets for addressing cumulative effects), review and feedback on impact studies in progress which can prevent duplicative efforts, and the review of environmental impact analyses via environmental assessments (EAs) or draft EISs (Clark, 1994). In the EIA practice in the United States, EAs refer to preliminary studies conducted to determine whether the impacts will be significant and thus the necessity of preparing EISs.

To summarize the public involvement component, scoping in relation to the inclusion of contacts with others and consideration of their viewpoints should be (Council on Environmental Quality, 1981 and 1986):

(1) open to the public and state and local governments, as well as to affected federal agencies--proponent agencies will likely overlook projects, data, and ongoing plans in a community unless the scoping is inclusive;

(2) considered as a process and not simply an event or meeting; in particular, it is not a "public relations" meeting requirement--in fact, scoping does not necessarily result in a public meeting;

(3) inclusive of a series of meetings (could be public meeting or meetings with individual governmental agencies and nongovernmental organizations -- NGOs), telephone conversations, and/or receipt of written comments from different interest groups; and

(4) focused on identifying individuals (or agencies or NGOs) who already have knowledge about a site or an alternative proposal or a relevant study, and encourage them to make it available.

Related to substantive issues to be identified, including cumulative effects, the focus of the scoping process should not be limited to impacts on the physical-chemical and biological features of the affected environment. Impacts related to sociocultural and socioeconomic issues should also be given attention and incorporated, as appropriate, in the subsequent EIS (Howell, 1993; and Canter and Clark, 1997). This is important in the EIA process in the United States because the term "environment" is defined to include physical-chemical, biological, cultural, and socioeconomic features. Further, it should be recognized

Table 4.2: Practical Aspects and Components of the Scoping Process (after Council on Environmental Quality, 1978)

As soon as practicable after its decision to prepare an EIS and before the scoping process the lead agency shall publish a notice of intent in the Federal Register.

(a) As part of the scoping process, the lead agency shall:

(1) Invite the participation of affected federal, state, and local agencies, any affected Indian tribe, the proponent of the action, and other interested persons (including those who might not be in accord with the action on environmental grounds).
(2) Determine the scope and the significant issues to be analyzed in depth in the EIS.
(3) Identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review (narrowing the discussion 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).
(4) Allocate assignments for preparation of the EIS among the lead and cooperating agencies, with the lead agency retaining responsibility for the statement.
(5) Indicate any public EAs and other EISs which are being or will be prepared that are related to but are not part of the scope of the impact statement under consideration.
(6) Identify other environmental review and consultation requirements so the lead and cooperating agencies may prepare other required analyses and studies concurrently with, and integrated with, the EIS.
(7) Indicate the relationship between the timing of the preparation of environmental analyses and the agency's tentative planning and decision-making schedule.

(b) As part of the scoping process, the lead agency may:
(1) Set page limits on environmental documents.
(2) Set time limits.
(3) Adopt procedures to combine its EIA process with its scoping process.
(4) Hold an early scoping meeting or meetings which may be integrated with any other early planning meeting the agency has. Such a scoping meeting will often be appropriate when the impacts of a particular action are confined to specific sites.

(c) An agency shall revise the determinations made under paragraphs (a) and (b) if substantial changes are made later in the proposed action, or if significant new circumstances or information arise which bear on the proposal or its impacts.

that cumulative effects assessments (CEAs) have typically focused on biophysical consequences, with only limited attention to socio-cultural concerns. Therefore, cumulative effects on socio-cultural (socioeconomic) features of the study area are particularly important to identify during the scoping process.

Finally, while the law and practice in the United States has emphasized scoping in the preparation of EISs, the ever increasing reliance on EAs with mitigation make scoping in EAs more necessary and useful. The resultant document may be called a "mitigated FONSI" (finding of no significant impact). Making decisions about the scope of mitigation and the requirements of monitoring is as important as determining what to study and who should be involved in the study. Further, since cumulative effects should be considered in EAs, any scoping related to EAs should at least explore the topic of cumulative effects concerns. As in normal scoping, appropriate public notice is required, as well as adequate information on the proposal to make scoping worthwhile. But scoping at this early stage cannot substitute for the normal scoping process unless the earlier public notice stated clearly that this would be the case, and the subsequent notice of intent expressly provides that written comments suggesting impacts and alternatives for study will still be considered (Council on Environmental Quality, 1981 and 1986).

FEDERAL AGENCY INVOLVEMENT

Federal agencies in the United States initiate or participate in the scoping process for one or more of the following reasons (U.S. Environmental Protection Agency, 1984): (1) planning and implementation of a scoping program for a proposed action wherein the agency is the lead agency; (2) serving as a cooperating agency to a lead agency for a proposed action, thus involving participation in (and possibly some planning for) the scoping process; and/or (3) participation in the scoping process for a proposed action of another lead agency, including responding to scoping requests and providing input regarding the proposed action. Cumulative effects identification and prioritization could be incorporated in each of these reasons.

Because of their potential involvement in planning and implementing scoping programs, agencies typically address scoping in their respective EIA guidelines. For example, Sec. 230.12 of the U.S. Army Corps of Engineers guidelines addresses the notice of intent and scoping (U.S. Army Corps of Engineers, 1988).

> As soon as practicable after a decision is made to prepare an EIS or supplement, the scoping process for the draft EIS or supplement will be announced in a notice of intent. Guidance on preparing a notice of intent to prepare an EIS for publication in the Federal Register is discussed in Appendix C of these guidelines. Also, a public notice will be widely distributed inviting public participation in the scoping process. This process is the key to preparing a concise EIS and clarifying the significant issues to be analyzed in depth. Public concerns on issues, studies needed, alternatives to be examined, procedures and other related matters will be addressed during scoping.

GENERAL PLANNING CONSIDERATIONS FOR A SCOPING PROGRAM

The CEQ regulations are generally flexible in all areas and, in the case of scoping, leave the detailed aspects of the scoping process to the

federal agency serving as the lead agency (Mandelker, 1995). Therefore, specific planning for an appropriate scoping process for a proposed action, including cumulative effects considerations, is needed on the part of the lead (proponent) agency. Accordingly, four elements can be considered as fundamental to planning a scoping program for each proposed action: (1) delineation of the scoping objectives--these could include generic objectives as per the CEQ regulations, as well as specific objectives related to the unique proposed action in the specific geographical location; (2) identification of the publics (stakeholders) who should be contacted and invited to participate in the scoping process; (3) selection of one-to-several public participation techniques to be used to provide information about the proposed action and to solicit input from the interested publics; and (4) development of a strategy for analyzing the provided inputs and their use in the prioritization of issues to be addressed in the impact study, including cumulative effects issues. The fourth element is the basis for the analytical considerations to be described in the next section.

Everitt (1995) has suggested that there are two key concepts associated with the scoping process and, by inference, planning the process: (1) consultation with stakeholders (various publics) to identify issues and concerns; and (2) evaluation and prioritization of identified issues. A "public" can be defined as any person, or group of people, that has a distinctive interest or stake in an issue (Federal Environmental Assessment Review Office, 1988). Publics can be categorized in many ways; examples include: (1) geographical proximity to the proposed action; (2) focused on economic development; (3) focused on environmental protection or preservation; (4) governmental agencies with differing environmental interests and responsibilities; (5) professional societies and interest groups; and/or (6) "nongovernmental organizations" (NGOs), including a diversity of groups ranging from preservationists to labor unions to "green movement" entities.

Some pragmatic considerations in planning a scoping program are highlighted in Table 4.3 (Council on Environmental Quality, 1981 and 1986). Such considerations are related to timeliness, information communication, and follow-on usage of the inputs from various publics. These considerations represent fundamental concerns in planning an effective scoping program for a proposed action. Item (6) in Table 4.3 highlights the need to prioritize and select relevant issues.

Identification of Relevant Publics

Four broad approaches can be used to target relevant publics for inclusion in scoping programs: (1) there are always inherent interests in a project; thus local and regional governmental entities are one group of publics; (2) self-identification; (3) third-party identification; and (4) identification by staff of the lead (proponent) agency (Creighton, 1981). "Self-identification" simply means that individuals or groups step forward and indicate an interest, either pro or con, in the scoping process. The use of the news media, the preparation of brochures and newsletters, and the conduction of well-publicized public meetings are all means of encouraging continuing self-identification. Third-party and staff identification are self-explanatory as targeting approaches.

Techniques for Information Communication

The public can participate effectively only if it has been provided with accurate information about the proposed action. Numerous techniques exist for communicating with identified publics, but special attention

Table 4.3: Pragmatic Considerations in Planning a Scoping Program for a Proposed Action (after Council on Environmental Quality, 1981 and 1986)

1. Start Scoping After You Have Sufficient Information
   Scoping cannot be useful until the lead agency knows enough about the proposed action to identify most of the affected parties and to present a coherent proposal and a suggested initial list of environmental issues and alternatives.

2. Prepare an Information Packet
   In many cases, scoping of the EIS has been preceded by preparation of an EA as the basis for the decision to proceed with an EIS. In such cases, the EA will, of course, include the preliminary information that is needed. If you have not prepared an EA, you should put together a brief information packet consisting of a description of the proposal, an initial list of impacts and alternatives, maps, drawings, and any other material or references that can help the interested public to understand what is being proposed.

3. Design the Scoping Process for Each Project
   There is no established or required procedure for scoping. The process can be conducted by meetings, telephone conversations, written comments, or a combination of all three. It is important to tailor the type, the timing, and the location of public and agency comments to the proposal at hand. If you decide that a public meeting is appropriate, you still must decide what type of meeting, or how many meetings, to hold.

4. Issue the Public Notice
   A preliminary review of the proposal, from which you develop the information packet discussed above, will enable you to tell what kind of public notice will be most appropriate and effective. Section 1501.7 of the NEPA regulations requires that a notice of intent to prepare an EIS must be published in the Federal Register prior to initiating scoping. This means that one of the appropriate means of giving public notice of the upcoming scoping process could be the same Federal Register notice. But use of the Federal Register is not an absolute requirement, and other means of public notice often are more effective, including local newspapers, radio and TV, posting notices in public places, etc. What is important is that the notice actually reach the affected public.

Table 4.3 (continued):

5. Conduction of a Public Meeting
One of the most important factors in a successful scoping process is the training and experience of the meeting moderator. Training courses on how to conduct a meeting effectively can be useful. Specific techniques can be taught to keep the meeting on course and to deal with confrontations. These techniques are sometimes called "meeting facilitation skills." When holding a meeting, the principle thing to remember about scoping is that it is a process to initiate preparation of an EIS (or EA). It is not concerned with the ultimate decision on the proposal. At the point of scoping therefore, in one sense all the parties involved have a common goal, which is a thorough environmental review. Finally, informal meetings in small groups are the most satisfactory for eliciting useful issues and information. Small groups can be formed in two ways: you can invite different interest groups to different meetings, or you can break a large number into small groups for discussion. One member of the lead agency or cooperating agency staff should join each group to answer questions and to listen to the participants' expressions of concern. It has been the experience of many of those who have tried this method that it is better not to have the agency person lead the group discussions. There does need to be a leader, who should be chosen by the group members. In this way, the agency staff member will not be perceived as forcing his/her opinions on the others.

6. Determine What to Do with the Comments
After you have comments from the cooperating agencies and the interested public, you must evaluate them and make judgments about which issues are, in fact, significant and which ones are not. The decision of what the EIS (or EA) should contain is ultimately made by the lead agency. But you will now know what the interested participants consider to be the principal areas for study and analysis. You should be guided by these concerns, or be prepared to briefly explain why you do not agree. Every issue that is raised as a priority matter during scoping should be addressed in some manner in the EIS, either by in-depth analysis, or at least a short explanation showing that the issue was examined but not considered significant for one or more reasons.

7. Allocate Work Assignments and Establish Schedules
Following the public participation in whatever form, and the selection of issues to be covered, the lead agency must allocate the EIS (or EA) preparation work among the available resources. If there are no cooperating agencies, the lead agency allocates work among its own personnel or contractors. If there are cooperating agencies involved, they may be assigned specific research or writing tasks. The NEPA regulations require that they normally devote their own resources to the issues in which they have special expertise or jurisdiction by law. In all cases, the lead agency should set a schedule for completion of the work, designate a project manager, and assign the reviewers, and must set a time limit for the entire NEPA analysis if requested to do so by an applicant (project proponent).

must be paid to the kind of public that is participating. For example, participation of diverse groups is essential to establishing potential impacts on low-income communities. In some cases agencies should seek alternative methods to inform the public of a proposed action (e.g., video and computer demonstrations) as opposed to relying solely upon written and formulaic processes.

Some scoping techniques can encompass public meetings. Although this is the most common forum, its effectiveness is often minimized by the agencies' attempts to "sell" the project to the public, rather than scoping the boundaries of the study. Other examples of techniques include the use of letters, questionnaires, and telephone calls; hotlines; drop-in centers; workshops; citizens' advisory committees; and many others. Information on these techniques and others is in Canter (1996). For example, a videotape of proposed sites for a project is an excellent tool for explaining site differences and limitations during the lecture-format portion of a scoping meeting (Council on Environmental Quality, 1981 and 1986). Scoping workshops can also be useful, with their success, in large part, depending on the degree of advance preparation; therefore, such preparation should be as comprehensive as possible. Advance preparation for workshops might include distribution of various types of brochures, planning visits, coverage by the media, and direct contacts with interested parties. Finally, because scoping is grounded in public participation, individuals leading the scoping process need skills in planning such meetings, their productive management, and the defusing of possible heated disagreements.

Usage of Outcomes of the Scoping Process

The primary outcome of the scoping process should be a targeted range of issues and impacts to be addressed in the impact study. The impacts can include direct, indirect, and cumulative effects. Further, in some EIA systems, for example, in Canada, scoping can be used to establish the terms of reference (TOR) for such an impact study (Everitt, 1995). The TOR should specify the information and analysis required to conduct the assessment and to prepare an EIA report.

Scoping results can also be used in pre-or-post-EIS monitoring planning. For example, structured impact hypotheses which relate project actions to environmental linkages and valued ecosystem components (VECs) are used in some environmental impact studies. When such hypotheses are used, scoping can be defined as the procedure in which actions, linkages, and VECs are extracted from the conceptual model (Bernard, Hunsaker, and Marmorek, 1993). Scoping can thus be used in developing an environmental monitoring program for the proposed action, a portion of the program could be focused on cumulative effects. This type of scoping is often associated with highly focused interdisciplinary workshops conducted as part of the Adaptive Environmental Assessment and Management approach.

Other potential outcomes of the scoping process could include (Ashe and Sadler, 1995): (1) the refocusing of baseline studies and/or monitoring as appropriate; (2) the identification of suitable methodologies and methods for next-phase impact analysis and public consultation; (3) recognition that this process also constitutes a continuing rescoping exercise, track accordingly and maintain flexibility; and/or (4) the preparation of a scoping statement or report with brief updates as necessitated by changes.

Special Considerations for Transboundary Impacts

A final issue related to planning a scoping program may entail the need to address transboundary direct, indirect, and cumulative effects of proposed projects. A major step toward requiring that transboundary impacts be addressed for development projects resulted from a recent multination agreement, namely, the 1991 Convention on EIA in a Transboundary Context which was adopted by 28 countries and the European Community (Economic Commission for Europe, 1991). In February, 1992, the United States also signed the Convention (Council on Environmental Quality, 1993). The Convention stipulates the obligations of parties (signees or member countries) to carry out the assessment of environmental impacts and to arrange for the application of the assessment at an early stage of planning for certain activities likely to cause significant adverse transboundary effects. Public participation (presumably to include scoping) should be used in the EIA procedure at the project level, and foreign participants should be given the same opportunities for comment as those given to the local public (Lee, Walsh, and Jones, 1991).

A scoping program encompassing transboundary impacts (including cumulative effects) could encounter a variety of difficulties, particularly when two or more countries (or states in the United States) are involved. Examples of such difficulties which could arise during scoping include: (1) conflicts related to governmental development objectives for shared resources; (2) differences or incompatibilities between environmental standards and policies, and their enforcement; (3) nonuniformity of the number and types of governmental agencies addressing environmental media or natural resources; (4) conflicts in viewpoints expressed by various publics from different geographical entities; (5) coordination difficulties with multiple governmental agencies in potentially affected areas; (6) different and possible conflicting mitigation requirements proposed as a basis for project concurrence by relevant agencies in potentially affected areas; and (7) EIA policy and procedural differences between countries (or other political boundaries).

ANALYTICAL CONSIDERATIONS IN SCOPING FOR CUMULATIVE EFFECTS

The scoping process should be based on an analytical approach which involves: (1) breaking the proposed action into relevant parts and establishing the relationships between the parts and their environmental consequences; and (2) prioritization of received issues and impact information from the scoping process based on both baseline environmental conditions and anticipated changes. The first part can be accomplished via careful delineation of the proposed action and related direct, indirect, and cumulative effects. The second part is more difficult to address. This difficulty is often demonstrated in EISs which report a list of identified issues and impacts from scoping, and then highlight a subset of issues/impacts without a clear delineation of why the subset items were chosen.

Three issues are of particular importance in scoping for cumulative effects: (1) the preparation (homework) of the study team relative to identifying cumulative effects for the proposed action and related actions prior to any public scoping activities; (2) the realization that the scoping process is iterative regarding identifying, sharpening, and prioritizing cumulative effects concerns; and (3) the absolute necessity to document the process, findings, analysis, and results. Attention herein will be primarily related to the identification of cumulative effects.

Methods for Identifying Cumulative Effects

Some key questions which can be used to identify cumulative effects to explore prior to and during the scoping process include:

(1) Regarding the proposed action:

(a) is it a programmatic action or is it a project that is part of a larger program?

(b) is it part of a continuing activity?

(c) is it is part of a larger action (a segment) such that it is connected to other actions?

(d) are there other types of present and reasonably foreseeable future actions by the proponent agency which will be in the proximity of the proposed action?

(2) What other present and reasonably foreseeable future actions are in progress or are being planned by other governmental agencies and the private sector?

(3) Are cumulative effects of sufficient concern (of such potential significance) that they should be considered in the EIS (or EA)?

(4) Which types of cumulative effects (e.g., additive, countervailing, or synergistic from single or multiple actions) on which resources, ecosystems, and/or human communities should be addressed in the EIS (or EA)?

(5) Are there obvious indicators which could be used for the cumulative effects?

(6) Are there analogs (case studies) which may have relevance for the cumulative effects of concern?

(7) What are the appropriate geographical boundaries for encompassing the cumulative effects of concern? What scientific and/or policy bases should be used in establishing such boundaries? (This is a particularly important consideration which should be addressed in the scoping process).

(8) What are the appropriate temporal boundaries and what considerations should be used in establishing such boundaries? (This is also a particularly important consideration in scoping for cumulative effects).

(9) What criteria should be used in determining a significant cumulative effect?

(10) Are there sources of information for existing environmental conditions related to the cumulative effects of concern? See Table 4.4 for examples of information sources (Council on Environmental Quality, 1997). Is there relevant information on planning goals, guidelines, standards, thresholds, carrying capacity, and/or limits of acceptable change for the resources, ecosystems, and/or human communities of concern?

Table 4.4: Examples of Sources of Information for CEA (after Council on Environmental Quality, 1997)

Individuals	• former and present landholders • long-time residents • long-time resource users • long-time resource managers
Historical societies	Local, state, and regional societies could provide: • personal journals • photos • newspapers • individual contacts
Schools and universities	• central libraries • natural history or cultural resources collections or museums • field stations • faculty in history, natural and social sciences, and engineering
Other collections	Private, city, state, or federal collections in: • archaeology • botany • zoology • natural history
Natural history surveys	• private • state • national
Private organizations	• land preservation • habitat preservation • conservation • cultural resources history • religious institutions • chambers of commerce • voluntary neighborhood organizations
Government agencies	• local park districts • local planning agencies • local records-keeping agencies • state and federal land management agencies • state and federal fish, wildlife, and conservation agencies • state and federal environmental regulatory agencies • state planning agencies • state and federal records-keeping agencies • state and federal surveys • state and federal agricultural and forestry agencies • state historic preservation offices • Indian tribal government planning, natural resource, and cultural resource offices
Project proponent	• project plans and supporting environmental documentation

Some sources of information (or approaches) which can be used for identifying cumulative effects prior to or during the scoping process include:

(1) Professional knowledge and experience of individuals (yourself and individual interdisciplinary EIA study team members, if appropriate); and the collective knowledge and experience of the study team following site visits and team discussions. Of critical importance is for individuals and the team to be sensitive to incremental impacts and possible cumulative effects during conduction of the EIA process. See Table 4.5 for some additional "prompter questions" to consider in identifying potential cumulative effects (Council on Environmental Quality, 1997).

(2) Review of planning activities of the proponent agency and other potentially relevant agencies (or private sector developers). Three examples of planning activities which should be explored during scoping include: (1) the planning which resulted in the proposed action; (2) other planning by the proposing agency; and (3) planning activities of other governmental agencies or private sector developers. The individuals who planned the proposed action should be consulted to determine whether the proposed action is one of several similar actions to be proposed (multiple similar actions) or whether the proposed action is closely related or phased with other actions (connected actions). These reviews can be useful in identifying both present and reasonably foreseeable future actions.

(3) Consultations on potential cumulative effects, via phone, letter, e-mail, or in person, with individuals or key organizational representatives within the proponent agency, other agencies, regulatory authorities, regional planning organizations, private industrial and/or housing development organizations, public interest groups, and environmental NGOs. Such consultations could be held during both scoping for an EA and an EIS.

(4) Solicitation of the expert opinion of other experienced EIA professionals, or substantive area experts, regarding potential types of cumulative effects associated with the proposed action in its spatial and temporal context.

(5) Conduction of reviews of published literature on: (1) typical cumulative effects concerns for the type of proposed action; (2) typical cumulative effects concerns for the types of resources, ecosystems, and human communities in the vicinity of the proposed action; (3) case studies which have been conducted for similar types of proposed actions; and (4) general cumulative effects studies, for example, watershed studies focused on cumulative effects on water quality or quantity due to land use alterations in the drainage area.

(6) Conduction of briefings followed by question/answer sessions in small to large public meetings. The meetings can range from informal gatherings to the receipt of testimony from a large number of people which is transcribed by a court reporter.

Table 4.5: Questions for Identifying Potential Cumulative Effects (after Council on Environmental Quality, 1997)

1.	What is the value of the affected resource or ecosystem? Is it: • protected by legislation or planning goals? • ecologically important? • culturally important? • economically important? • important to the well-being of a human community?
2.	Is the proposed action one of several similar past, present, or future actions in the same geographic area? (areas could be land management units, watersheds, regulatory regions, ecoregions, etc.)
3.	Do other activities (whether governmental or private) in the same geographic area have environmental effects similar to those of the proposed action?
4.	Will the proposed action (in combination with other planned activities) affect any natural resources; cultural resources; social or economic units; or ecosystems of regional, national, or global public concern?
5.	Have any recent or ongoing NEPA analyses of similar actions or nearby actions identified important adverse or beneficial cumulative effect issues?
6.	Has the impact been historically significant, such that the importance of the resource is defined by past loss, past gain, or investments to restore resources?
7.	Might the proposed action involve any of the following cumulative effects issues? • long range transport of air pollutants resulting in ecosystem acidification or eutrophication • air emissions resulting in degradation of regional air quality • release of greenhouse gases resulting in climate modification • loading large water bodies with discharges of sediment, thermal, and toxic pollutants • reduction or contamination of ground water supplies • changes in hydrological regimes of major rivers and estuaries • long-term containment and disposal of hazardous wastes • mobilization of persistent or bioaccumulated substances through the food chain • decreases in the quantity and quality of soils • loss of natural habitats or historic character through residential, commercial, and industrial development • social, economic, or cultural effects on low-income or minority communities resulting from ongoing development • habitat fragmentation from infrastructure construction or changes in land use • habitat degradation from grazing, timber harvesting, and other consumptive uses • disruption of migrating fish and wildlife populations • loss of biological diversity

(7) Review of public opinion information about local valuable resources and ecosystems, stressed environmental situations in the local or regional area, and the proposed action itself.

(8) Review of relevant NEPA documentation prepared by the proponent agency and other agencies with projects in the vicinity of the proposed action. Such documentation should include both EISs and EAs.

Finally, numerous methods (tools) have been utilized over the last 25 years to meet the various activities required in the conduction of impact studies. Several such EIA methods can be used to facilitate the identification of direct, indirect, and cumulative effects and related issues during the scoping process. Examples of pertinent methods for cumulative effects include: analogs, checklists, expert opinion, expert systems, literature reviews, interaction matrices, monitoring of receptors near analogs, networks, overlay mapping, and risk assessment. Table 4.6 contains brief descriptions of each of these 10 types of methods. Of the listed methods, analogs, checklists focused on cumulative effects (like the list of questions in Table 4.5), expert opinion, literature reviews, interaction matrices, and networks appear to be most useful at this time.

Prioritization and Selection

Prioritization and selection of identified issues and impacts, including cumulative effects, can be achieved via a direct professional judgment approach or a qualitative review approach which incorporates professional judgment. A necessary feature of either approach is the careful documentation of the analytical process and its results. As noted, professional judgment is actually involved in both approaches, with the distinction in the first approach being that issues are chosen based upon the professional knowledge and judgment of individuals on an interdisciplinary study team, or the collective judgment of the study team as a whole. In this regard, specific decision criteria for comparing issues may not be delineated, with choices probably being related to the familiarity and possible previous experience by individuals on the team. When effects (including cumulative effects) and issues are selected based on qualitative comparisons, these selections are typically made based on identifying decision criteria and then comparing candidate effects and issues, possibly on a relative basis, in conjunction with each of the listed criteria. The typical process involves: (1) the identification of decision criteria for issues; (2) the qualitative comparison of candidate issues relative to the decision criteria; and (3) the selection of issues for inclusion based on the information in (2) coupled with professional judgment. Usage of this three-step approach can facilitate the necessary documentation of the selection process.

Examples of some decision criteria which might be used in the scoping process for cumulative effects include:

(1) vulnerability of resources, ecosystems, and human communities to changes (stresses);

(2) compatibility with land use policies and plans;

(3) compliance with environmental standards for air, surface water, ground water, and soil quality;

(4) thresholds and carrying capacities for resources, ecosystems, and human communities;

Table 4.6: Brief Descriptions of 10 Types of Methods Potentially Useful in Scoping for Cumulative Effects

(1)	Analogs refer to information from existing projects of a similar type to the project being addressed, with monitoring information related to experienced impacts being used as an analogy to the anticipated impacts of the proposed project.
(2)	There are many variations of checklists, with this type of methodology being a frequently utilized approach. Conceptually, checklists typically contain a series of items, impact issues, or questions which the user should address.
(3)	Expert opinion, also referred to as professional judgment, represents a widely used method. Specific tools which can be used to facilitate information development include the conduction of Delphi studies, the use of the adaptive environmental assessment process to delineate qualitative/quantitative models for impact prediction, or the separate development of models for environmental processes.
(4)	Expert systems refer to an emerging type of method which draws upon the professional knowledge and judgment of experts in particular topical areas. Such knowledge is encoded, via a series of rules or heuristics, into expert system shells in computer software.
(5)	Literature reviews refer to assembled information on types of projects and their typical impacts. As noted for analogs, such information can be useful for delineating potential impacts, quantifying anticipated changes, and identifying mitigation measures.
(6)	Interaction matrices represent a widely used type of method within the EIA process. Variations of simple interaction matrices have been developed to emphasize particular desirable features.
(7)	Monitoring (field studies) of receptors near analogs represents a specialized approach in that monitoring can be conducted of actual impacts resulting from projects of a similar type to the project being analyzed.
(8)	Networks delineate connections or relationships between project actions and resultant impacts. They also referred to as impact trees, impact chains, cause-effect diagrams, or consequence diagrams. Networks are useful for showing primary, secondary, and tertiary impact relationships.
(9)	Overlay mapping was used early in the practice of EIA, with the usage consisting of the assemblage of maps overlying a base map and displaying different environmental characteristics. The application of geographical information systems (GIS) via computer usage has been an emphasis in recent years, with this technology representing an emerging type of method.
(10)	Risk assessment refers to an emerging tool initially used for establishing health-based environmental standards. It encompasses the identification of the risk, consideration of dose-response relationships, conduction of an exposure assessment, and evaluation of the associated risks. Risk assessment can be viewed from the perspective of both human health and ecological risks.

(5) effect on protected areas;

(6) effect on threatened/endangered species, or cultural resources;

(7) compatibility with sustainable development principles;

(8) disagreement among experts as to the significance of anticipated cumulative effects;

(9) level of public concern regarding cumulative effects;

(10) mitigation possibilities for significant cumulative effects;

(11) "added value" to decision-making of information if addressed (time to address, etc.); and

(12) likelihood of a lawsuit if cumulative effects are not properly addressed.

Table 4.7 illustrates how the candidate effects and issues can be displayed versus the decision criteria. The "three level comparison code" can be used to rate each effect or issue relative to each criterion. Summation of the types of codes assigned to each issue can be useful in prioritization and selection of cumulative effects (as well as other effects and issues). In the illustration in Table 4.7, candidate effects or issues 1 and 2 should be included in the scope of the impact study, (number 1 has 2 Ps, 1 M, and 2 Ns; while number 2 has 5 Ps), while number 5 could be excluded (it has 5 Ns). Issues 3 and 4 could be eliminated following a brief review of the listed "M" codes for each.

Research Needs

The majority of the attention given to scoping in published literature is associated with identifying various publics and using a variety of public participation techniques to accomplish scoping. What is often unclear is the relationship between information gathered during various scoping activities and the actual selection of informational topics (including cumulative effects) for inclusion in the subsequent impact study. This concern was addressed in a scoping workshop at the Sixteenth Annual Meeting of the International Association of Impact Assessment held in Estoril, Portugal in June, 1996. The following "research needs" were identified regarding improvements in the analytical nature of scoping for direct, indirect, and/or cumulative effects in the EIA process:

(1) It is important that consideration be given to the delineation of criteria which could be used for determining either the importance of existing environmental resources or the importance of anticipated impacts (including cumulative effects), with such criteria then used for purposes of evaluation of the information gathered during scoping. These criteria can form the basis for the actual selection process for items to be addressed in the impact study.

(2) Simple tools are need to determine environmental suitability or vulnerability, with such tools then used for purposes of identifying critical environmental resources that might be cumulatively impacted by a proposed project and related projects. Such a suitability or vulnerability analysis could

Table 4.7: Example of Decision Matrix for Qualitative Review Approach

Candidate Effects and Issues	Decision Criteria*				
	a	b	c	d	e
1	M	P	P	N	N
2	P	P	P	P	P
3	N	M	M	N	N
4	N	N	N	M	N
5	N	N	N	N	N

P = the decision criteria is pertinent to the effect or issue, thus suggesting the inclusion of the effect or issue in the impact study.
M = the decision criteria may be pertinent to the effect or issue, thus suggesting the gathering of additional pertinent information prior to making a decision for inclusion.
N = the decision criteria is not relevant to the effect or issue, thus it will not be necessary to address the effect or issue beyond documenting its consideration and elimination.
*The decision criteria could be expressed in the form of questions.

be presented in scoping meetings or be developed as one component of the analytical process following such meetings.

(3) An important aspect of the scoping process is related to how it can be used to identify potential mitigation measures or alternatives which could be considered in conjunction with the proposed project and cumulative effects of concern.

(4) It is also noted that the majority of scoping efforts to date have been oriented to specific projects, with less experience gathered on scoping for strategic environmental assessment (SEA) which addresses policies, programs, or plans. The scoping process as applied to SEA and cumulative effects should be considered in terms of a complete range of research needs and opportunities.

KEY LESSONS RELATED TO SCOPING

Four key lessons can be identified from collective experiences on planning and implementing the scoping process in the United States over the last 15(+) years. These lessons can be categorized into perspective, planning, prioritization, and performance categories. The "perspective lesson" is fundamental; that is, the scoping process (including scoping for cumulative effects) should be viewed as an opportunity to gather pertinent information so as to make the EIA process more efficient and effective. Scoping should not be perceived as another bureaucratic requirement to be met, with the "requirement" detracting from the opportunity to do substantive work on the impact study for the proposed action.

Several "planning lessons" can be identified, including a fundamental point that the scoping process for a specific proposed action needs to be tailored to the type of action, geographical location, and potentially affected publics. Numerous techniques exist for achieving effective public participation in the scoping process. Several techniques focused on different publics should probably be used in a scoping program. Also, individuals serving as leaders in scoping efforts should be professionally committed to the solicitation of public viewpoints and trained in the facilitation of public meetings.

The "prioritization lesson" relates to the need for the lead (proponent) agency to prioritize the inputs received during the scoping process. Additional attention needs to be given to systematic approaches which can be used by the lead agency in prioritizing issues and impacts (including cumulative effects) into those to be addressed in the EIS (or EA), and those which were considered and eliminated for whatever reason. The majority of the published literature and experience on scoping has focused on incorporating public participation to facilitate the identification of impacts and issues; considerably less attention has been given to subsequent prioritization needs.

The "performance lesson" relates to the need for careful documentation of the scoping process within the subsequent EIS (or EA). Such documentation should include, as a minimum, a clear description of the process, the received inputs related to impacts and issues, and how each such impact or issue (including each potential cumulative effect) was prioritized and addressed/not addressed within the EIS (or EA). Much of this documentation could be included in a supporting appendix to the EIS (or EA).

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CHAPTER 5

METHODS FOR CEA

and procedure

The focus of this chapter is on methods which can be used to accomplish one or more purposes in a CEA. Sections are included on desirable characteristics of methods, comparative reviews of methods, and examples of methods used in CEA studies. Also included is information on several approaches for selecting a method.

DESIRABLE CHARACTERISTICS OF CEA METHODS

Several authors have delineated desirable characteristics for CEA methods. The following information, which is arranged in chronological order, illustrate the ranges of identified characteristics. In an initial list, Horak, Vlachos, and Cline (1983) identified eight desirable characteristics of a CEA method: (1) emphasis on multiple projects and actions; (2) consideration of off-site impacts and effects; (3) interaction and synergism among actions, impacts, and effects; (4) ability to aggregate effects; (5) consideration of ecological functional aspects; (6) consideration of ecological structural aspects; (7) ability to predict; and (8) adaptability. They then evaluated 64 extant EIA and impact prediction methods relative to these eight criteria and determined that most did not meet them.

Witmer (1985) identified the following desirable characteristics of any method used for CEA: (1) it should specifically address multiple projects or activities; (2) it should be flexible and allow for adaptation to the basin-specific array of possible site-variable-impact combinations; (3) it should incorporate the analysis of a large geographic region with flexible boundaries; (4) it should be designed to identify cumulative effects and other developmental activities that may occur over an extended time frame; (5) it should specifically address interactions and synergisms and incorporate an approach for aggregating impacts; (6) it should incorporate public participation in the process; and (7) it should be practical in terms of time and monetary requirements.

Irving, et al. (1986) identified the following criteria (or features) which a CEA methodology should exhibit: (1) it should specifically address multiple developments or land use practices; (2) it should incorporate scoping to facilitate the narrowing of the list of potential impacts and impacted species and resources; (3) it should be adaptable to allow for the large array of possible site-resource-impact combinations; (4) it should have flexible boundaries in time and space because significant cumulative effects may occur offsite (at least in the traditional sense) or over an extended time frame; (5) it should be able to aggregate or tally incremental and interactive effects to give an estimate of the overall amount of effect to which a species or resource is being exposed; and (6) it should allow for differential levels of resolution, that is, it should allow for a more general, extensive analysis of the cumulative effects of all relevant developments, projects, or land use practices, while still allowing intensive site- and project-specific impact analysis.

To illustrate pertinent criteria for a particular type of project, Stull, et al. (1987) indicated that an appropriate CEA methodology for multiple hydroelectric development projects should include procedures for: (1) evaluating the combined effects of more than one action; (2) evaluating nonadditive, as well as additive, relationships between projects; (3) assessing the combined indirect effect of projects on fish

and wildlife populations, in addition to direct effects on the physical environment and fish and wildlife habitats; and (4) assessing pertinent types of effects to selected local species of fish and wildlife.

Contant and Wiggins (1993) proposed that an ideal CEA methodology should: (1) provide for the monitoring of development activity over time and space, as well as changes in selected environmental parameters in the study area over time; (2) incorporate clear and accurate models of the responses of natural systems affected by expected development activities; and (3) include effective environmental management systems which facilitate the evaluation of the cumulative effects and the initiation of appropriate management efforts. Drouin and LeBlanc (1994) suggested that a CEA method should facilitate the identification of interactions between the human and physical environment; enable the qualitative or quantitative modeling of stress-response complexities for biophysical and socio-economic indicators; and show ecological structural-functional relationships, especially storage, linkages and feedbacks.

In addition, and while writing from the perspective of CEA practice in New Zealand, Dixon and Montz (1995) said that CEA methods should exhibit the following characteristics: (1) some representation of interaction; (2) incorporation of impacts as they occur over space; (3) incorporation of impacts as they occur over time; and (4) the ability to trace impacts through from first-order, direct impacts to second-, third-, and fourth-order indirect impacts.

In 1995, Smit and Spaling described six criteria which could be used in the evaluation of potential methods for use in CEA. The criteria, which are shown in Table 5.1, encompass how the methods address temporal and spatial accumulation of changes, single or multiple perturbations, processes of accumulation via various pathways, and functional and structural changes within environmental systems.

Regarding practical methodologies for use in CEA, Damman, Cressman, and Sadar, (1995) indicated that such methods should be: (1) "doable" given the available environmental information, time and financial resources; (2) based on available data and applicable impact prediction techniques; (3) related to agency responsibilities for implementing the findings; (4) focused, as on impacts to valued ecosystem components, to allow for adequate attention on the most important environmental features and processes; (5) linked to criteria for assessing the significance of predicted cumulative effects; (6) traceable with the ability to identify the relationships between predicted effects and the recommendations for policy, mitigation, and monitoring; and (7) able to lead to conclusions about the most cost-effective approach to impact mitigation and monitoring.

Finally, the CEQ in the United States listed the following criteria questions for consideration in selecting a CEA method (Council on Environmental Quality, 1997a):

or procedure

(1) Whether the method can be used to assess:

- effects of same and different nature
- temporal change
- spatial characteristics
- structural/functional relationships
- physical/biological/human interactions
- additive and synergistic interactions
- delayed effects
- persistence of impacts

Table 5.1: Six Evaluation Criteria for Types of Methods (Smit and Spaling, 1995)

Name	Description
Temporal Accumulation	Temporal accumulation occurs when the interval between one perturbation and succeeding perturbations is too small for an environmental system, or system component or process, to assimilate or recover from the perturbation. Temporal accumulation requires that a method consider time scale and frequency of a perturbation. A method should incorporate an extended time horizon to detect long-term, incremental environmental change, and also account for time lags.
Spatial Accumulation	Spatial accumulation occurs where the spatial proximity between perturbations is smaller than the distance required to remove or disperse the perturbations. A method should recognize the geographic scale of perturbations and set spatial boundaries accordingly. It should also account for cross-boundary movements at the same scale (e.g., intraregional) and movements between different scales (e.g., local to regional to global). A method should acknowledge variation in spatial density because perturbations and effects are differentiated over space. Configuration is a significant characteristic because some methods may be oriented toward a certain pattern (point, linear, areal) more than others. The ability to consider an areal pattern is particularly important because cumulative impact assessment is often conducted in a regional context.
Type of Perturbation	Perturbation type refers to a method's ability to account for perturbations that are single or multiple in kind. For a method to fulfill this criterion, it should recognize perturbations that originate from multiple sources, or the same source repeated over time or across space. A method should also consider whether an action stimulates or propagates additional developments that trigger further sources of perturbation.
Process of Accumulation	Processes of accumulation emphasize pathways or relationships that link cause and effect. A method should have the ability to trace and account for specific processes of environmental change. It should differentiate between additive and interactive processes, and incorporate a technique that aggregates the effect of each.
Functional Change	Functional effects refer to alterations to processes (e.g., energy flows, nutrient cycling, succession), or modifications to controlling properties (e.g., assimilation capacity, carrying capacity, thresholds). A method should be able to identify, analyze, and assess functional change in an environmental system, or a system component or process, after perturbation. The criterion of functional effects generally implies time-oriented changes and includes time-crowding, time lags, and triggers and thresholds.
Structural Change	Structural effects include population shifts, habitat modification, and alterations to geophysical resources (e.g., air, water, soil). Analogous to functional effects, a method should be able to identify, analyze, and assess structural change in an environmental system, or a system component or process, after perturbation. Structural change is viewed as essentially spatial and includes space-crowding, cross-boundary flows, and fragmentation effects.

(2) Whether the method can be used to:

- quantify effects
- synthesize effects
- suggest alternatives
- serve as a planning or decision-making tool
- link with other methods, and

(3) Whether the method is:

- validated
- flexible
- reliable and repeatable.

Still additional criteria for CEA methods can be delineated for specific studies. For example, methods may be needed for specific types of projects or proposed actions (e.g., grazing, fossil-fueled power plants, or transportation systems); for specific environmental media such as air, surface water, soil, or ground water; for specific land uses or ecological areas (e.g., urban areas, upland forests, wetlands, or coastal zones); or for specific fish or wildlife species or other biophysical or socio-economic indicators.

COMPARATIVE REVIEWS OF EIA/CEA METHODS

Numerous methods (tools) have been utilized since 1970 to meet the various activities required within the EIA process. The objectives of the various activities differ, as do the usable methods for each. For example, Table 5.2 delineates 22 types of methods arrayed against seven EIA typical study activities (Canter, 1997a). An "x" denotes that the listed method type is or may be directly useful for a given activity. The types of methods in Table 5.2 encompass many specific techniques and tools; the methods are listed alphabetically and not in order of importance or usage. Differential usage of methods has also occurred within EIA practice, and Table 5.3 summarizes the relative usage into three categories. Methods which are simpler in terms of data and personnel resources requirements, and in technical complexity, have been found to be more useful. These simpler methods include analogs, checklists, expert opinion (professional judgment), mass balance calculations, and matrices.

Applying the EIA process in a typical impact study requires the selection of one or more methods to meet identified study needs. Accordingly, consideration needs to be given to certain approaches which could be used in such a selection process. For some impact studies, the sponsoring agency (proponent) may specify the methods to be used. Depending upon the type of study, such methods may be dictated by proponent best practices or by statutory requirements. At the other extreme, and perhaps more typical of impact studies, is when the proponent does not specify any methods for usage with the presumption being that the professionals on the interdisciplinary team conducting the study will utilize appropriate methods depending upon the type of project, environmental setting, and study parameters such as time and funding. All impact studies require some methods selection, including those studies that have stipulations for the usage of particular methods due to statutory requirements. For example, it may be necessary to select one or methods for impact identification related to a proposed coal-fired power plant, but then to utilize a specified air quality dispersion model for addressing the atmospheric dispersion of sulfur dioxide from the plant stacks. To conclude, this brief review of EIA methods is germane since

Table 5.2: Synopsis of EIA Methods and Study Activities (Canter, 1997a)

Types of Methods in EIA	Define Issues (Scoping)	Impact Identification	Describe Affected Environment	Impact Prediction	Impact Assessment	Decision Making	Communication of Results
Analogs (look-alikes) (case studies)	X	X		X	X		
Checklists (simple, descriptive, questionnaire)		X	X				X
Decision-focused checklists (MCDM, MAUM, DA, scaling/rating/ranking, weighting)					X	X	X
Environmental cost-benefit analysis				X	X	X	
Expert opinion (professional judgment, Delphi, adaptive environmental assessment, simulation modeling)		X		X	X		
Expert systems (impact identification, prediction, assessment, decision making)	X	X	X	X	X	X	
Indices or indicators	X		X	X	X		X
Laboratory testing and scale models		X		X			
Landscape evaluation			X	X	X		
Literature reviews		X		X	X		
Mass balance calculations (inventories)				X	X		X
Matrices (simple, stepped, cross-impact, scoring)	X	X		X	X	X	X
Monitoring (baseline)			X		X		
Monitoring (field studies of receptors near analogs)				X	X		
Networks (impact trees/chains, cause/effect or consequence diagrams)		X	X	X			
Overlay mapping via GIS			X	X	X		X
Photographs/photomontages (historical and current)			X	X			X
Qualitative modeling (conceptual)			X	X			
Quantitative modeling (media, ecosystem, visual, archaeological, socio-economic, and simulation)			X	X			
Risk assessment (relative or quantitative and probabilistic)	X	X	X	X	X		
Scenario building				X		X	
Trend extrapolation			X	X			

Notes: X denotes potential for direct usage of method for listed activity
MCDM = multicriteria decision making
MAUM = multiattribute utility assessment
DA = decision analysis

Table 5.3: Summary of Relative Usage of Types of Methods in the EIA Process

Types of Methods	Relative Usage*		
	Selected	Moderate	Widespread
Analogs			X
Checklists			X
Decision-focused checklists	X		
Environmental cost-benefit analysis	X		
Expert opinion			X
Expert systems	X		
Indices or indicators		X	
Laboratory testing and scale models	X		
Landscape evaluation	X		
Literature reviews		X	
Mass-balance calculations			X
Matrices			X
Monitoring (baseline)	X		
Monitoring (analogs)	X		
Networks		X	
Overlay mapping via GIS	X		
Photographs/photomontages		X	
Qualitative modeling		X	
Quantitative modeling	X		
Risk assessment	X		
Scenario building	X		
Trend extrapolation	X		

* "Selected" refers to limited usage of type of methods; such limited usage could be due to data requirements, limited knowledge about the method, or the fact that it is an emerging method.

"Moderate" indicates that the type of method is used for different types of projects in different locations.

"Widespread" denotes that the type of method is widely used in a variety of countries with EIA requirements.

many of these types of methods can be used directly, or modified as appropriate, for usage in CEA studies.

Purposes for CEA Methods

Two main purposes can be identified for CEA methods: (1) to facilitate the identification of cumulative effects; and (2) for usage in the prediction of such effects. In this context, prediction refers to the quantification of the cumulative effects, if possible. If quantitative predictions are not achievable, qualitative (descriptive) predictions of cumulative effects can be used. Identification methods can be useful in scoping; establishing spatial and temporal boundaries for the study; selecting physical-chemical, ecological or socio-economic indicators of cumulative effects; determining what features to address in preparing a description of environmental baseline conditions; and in communicating study results relative to cumulative effects. Prediction methods are fundamental to delineating actual cumulative effects and to determining the significance of such effects in relation to thresholds and carrying capacities. Significance determinations are the key component within the impact assessment phase of the EIA process. The results from using these two types of methods can be incorporated within the decision-making phase of the EIA process. This phase may incorporate multicriteria decision-making methods, with one of the decision factors being the cumulative effects of the proposed action when considered in relation to other past, present, and reasonably foreseeable future actions in the study area.

Methods for CEA

A frequent rationale used to explain the lack of attention to CEA is the absence of appropriate methodologies. This viewpoint is probably erroneous if consideration is given to modifying extant EIA methods and applying them to address cumulative impact concerns. In fact, numerous methods can be identified; for example, 16 EIA/CEA methodologies were reviewed by Stull, et al. (1987a) regarding their usefulness for addressing cumulative effects from hydroelectric projects on fish and wildlife in the Columbia River Basin in the northwestern part of the United States. Table 5.4 lists the methodologies and their potential usefulness. Additional information on each method is available elsewhere (Stull, et al., 1987a). Most of the methodologies can be used to address multiple resources and multiple projects either directly or with modification. The Snohomish guidelines, Snohomish Valley environmental network, and the Swan River and Trinity Lakes methodologies focus on multiple resources but have no provisions for aggregating information across the resources. Most of the methodologies can be used to accumulate the effects of multiple projects in some way, although the HEP, IFIM, and Snohomish guidelines do not include specific accumulation procedures. Linear programming and multiattribute utility analysis would require modification to address cumulative effects from multiple projects. Finally, the AEAM methodology is unique since it does not specify any particular assessment procedures. Consequently, for this methodology, the accumulation and aggregation of effects will depend on the CEA study team. Based upon the systematic review of the 16 methodologies, Stull, et al. (1987a) concluded that none of them was entirely adequate for assessing the cumulative effects of hydroelectric development in the Columbia River Basin.

In a study related to assessing cumulative biological impacts, 12 potential methods used in EIA were reviewed in relation to 11 identified criteria (Granholm, et al., 1987). It was determined that none of the methods met all the criteria, although most of them were seen as useful

Table 5.4: Potentially Useful Methodologies for CEA of Multiple Hydroelectric Projects in a River Basin (after Stull, et al., 1987a)

Method	Classification*			
	A	B	C_1	C_2
Adaptive environmental assessment and management (AEAM) methodology				X
Argonne multiple matrix (AMM) methodology		X		
Cluster impact assessment procedure (CIAP)		X		
Habitat evaluation procedures (HEP)			X	
Instream flow incremental methodology (IFIM)			X	
INTASA methodology	X			
Linear programming				X
Multiattribute utility analysis				X
Snohomish guidelines		X		
Snohomish and Salmon River Basins methodology	X			
Snohomish Valley environmental network				X
Swan River assessment methodology	X			
Target approach	X			
Trinity lakes assessment methodology	X			
Water resources assessment methodology (WRAM)				X
Wetland functional assessment methodology			X	

*Classification A denotes that the method was specifically developed for CEA and that example case studies are available; B denotes a proposed CEA method but without published case studies; C denotes an EIA-related method that has been used in project-level EIA (C_1) or for environmental planning (C_2) -- these methods could be adapted for usage for various purposes in CEA.

for identifying potential cumulative effects. One deficiency was that the reviewed methods did not identify specific roles for the proponent or other interested parties in the CEA.

Ten types of CEA methods have been evaluated in relation to their ability to address multiple sources of cumulative environmental change, additive or interactive processes of accumulation, and various types of cumulative effects (Smit and Spaling, 1995). Table 5.5 summarizes features of the 10 types of methods, with the first six being analytical in nature, while the last four represent general planning methods (Smit and Spaling, 1995). The types of methods were then evaluated in relation to the six criteria in Table 5.1. The primary conclusion of the analysis was that there is no standard method for CEA among the variety of analytically and planning-oriented tools examined. Rather, the types of methods can be used for different purposes depending upon the needs of the specific study.

Table 5.6 identifies the strengths and weaknesses of nine types of methods which have been applied for CEA (Sadler and Verheem, 1996). Further, Table 5.7 contains summary descriptions of seven primary methods and four special methods which can be applied to CEA (Council on Environmental Quality, 1997a). Careful examination of the listed methods in Tables 5.5, 5.6, and 5.7 reveal some similarities across all three based on the terms used in Table 5.7 (matrices, networks and system diagrams, modeling, overlay mapping and GIS, and ecosystem analysis -- also includes landscape analysis and land suitability evaluation), or across two based on Tables 5.5 and 5.6 (expert opinion, programming models, and process guidelines). Unique methods include multi-attribute tradeoff analysis (Table 5.5), and questionnaires, interviews and panels, checklists, trends analysis, carrying capacity analysis, economic impact analysis, and social impact analysis (Table 5.7).

Because methods can be used for several purposes in a CEA study, consideration should be given to combining the results from the methods for various facets of the analysis. To illustrate, Figure 5.1 displays an approach for combining the results from several primary methods into an overall CEA (Council on Environmental Quality, 1997a).

Summary Observations on CEA Methods

The following observations can be made on the above-noted comparative reviews of CEA methods:

(1) The more recent reviews have tended to identified approximately 5 to 10 types of methods; however, the included types do not encompass all types of methods used in CEA, or which have been used in EIA and, with modification or adaptation, could be used in CEA.

(2) The reviews have tended to focus on CEA methods related to the biophysical environment, with rather limited attention given to methods related to cumulative effects on the socio-economic environment. This more narrow perspective probably reflects the state-of-practice of CEA, and the interests of the authors and funding agencies for the comparative studies.

(3) The methods are typically reviewed as a group without delineations of purpose (cumulative effects identification or prediction -- quantification), specificity (generic methods or methods for a type of project, or natural resource, or environmental media), category of effects (biophysical or

Table 5.5: Features of Ten Types of Methods for CEA (Smit and Spaling, 1995)

Category[a]	Main Feature	Mode of Analysis	Representative Method(s)
Spatial analysis	map spatial changes over time	sequential geographical analysis	Geographic information systems (GIS)
Network analysis	identify core structure and interactions of a system	flow diagrams; network analysis	Loop analysis Sorenson's network
Biogeographic analysis	analyze structure and function of landscape unit	regional pattern analysis	Landscape analysis
Interactive matrices	sum additive and interactive effects; identify higher order effects	matrix multiplication and aggregation techniques	Argonne multiple matrix; synoptic matrix; extended CIM[b]; modified CIAP[c]
Ecological modeling	model behavior of an environmental system or system component	mathematical simulation modeling	Hypothetical modeling of forest harvesting
Expert opinion	problem-solving using professional expertise	group process techniques (e.g., Delphi, nominal group technique)	Cause-and-effect diagramming
Multi-criteria evaluation	use of a priori criteria to evaluate alternatives	weighing of parameters and computational ranking of scenarios	Multi-attribute tradeoff analysis
Programming models	optimize alternative objective functions subject to specified constraints	mass-balance equations	Linear programming
Land suitability evaluation	use ecological criteria to specify location and intensity of potential land uses	define acceptable levels of ecosystem health and target thresholds utilizing ecological indicators	Land disturbance target Ecosystem-based planning
Process guidelines	logic framework to conduct CEA	systematic sequence of procedural steps	Snohomish guidelines CEA[d] decision tree

[a]: the first six categories include analytical methods; the last four are planning methods
[b]: CIM = cumulative impact matrix
[c]: CIAP = cumulative impact analysis process
[d]: CEA = cumulative effects assessment

Table 5.6: Summary Comments on Nine Methods for Addressing Cumulative Impacts (Sadler and Verheem, 1996)

GIS: Spatial analysis with the help of digital mapping. Strength: powerful and useful tool for carrying out spatial analysis of cumulative environmental change; applicable to mapping sources of cumulative environmental change and cumulative effects, with limited application for the analysis of pathways of cumulative change. Weakness: data requirements and variation in availability of data among different locales; inability to incorporate processes of accumulation.
Network analysis: e.g., "Loop analysis;" a qualitative, network technique that is based on feedback relationships. Strength: scores positive on most criteria; recommended for analysis of cumulative effects. Weakness: its application in CEA remains largely untested.
Biogeographic analysis (e.g., Landscape analysis): Landscape analysis emphasizes the spatial pattern of ecological components and processes within a defined land unit, usually a watershed or other naturally bounded region. Specific indicators that relate to structural and functional attributes at the landscape level are used to measure cumulative environmental change. For example, cumulative effects in bottom land hardwood forests: three indices for structural aspects (forest loss, forest contiguity, forest pattern), five indices for functional aspects (change in stream discharge, change in water residence time, trends in stream nutrient concentration, nutrient loading rates, native biotic diversity). Strength and weaknesses: see GIS.
Interactive matrices (e.g., Argonne multiple matrix): The Argonne multiple matrix was developed to analyze the additive and interactive effects of various configurations of multiple projects. The total cumulative effect of any configuration is assumed to be the sum of project specific effects adjusted for interactions among projects and their effects. Expert opinion is used to establish three types of data: scores that define the level of effect of each project on selected environmental components, weighting coefficients that reflect the relative value of each component, and interaction coefficients that measure the effect of each pair of projects on each component. These data sets are entered into matrices that are manipulated to calculate a total score indicating the cumulative effect for each project configuration. Strength: consideration of the cumulative effect of multiple sources of environmental change. Weakness: cumulative effects are not differentiated by type, and parameter values rely extensively on expert judgment.
Ecological modeling: (computer) modeling of ecosystems. Strength: theoretically, method scores very positive on a number of criteria. Weakness: application is dependent on reliable data, model validation and resources (time, money, expertise); models usually analyze the effect of multiple sources on only one environmental component; only applicable to environmental systems for which the system organization and behavior are reasonably well understood.
Expert opinion: Use of experts (e.g., in "cause and effect diagramming" in flow diagrams). Strength: provides an organizing framework for more empirical analyses. Weakness: scores negative on a number of CEA criteria.
Programming models (e.g., Linear programming): Linear programming is a tool that identifies resource allocations (solutions) which are feasible given specified environmental and other conditions (constraints), and then selects some "optional" allocation based on a specified decision rule (objective function). Strength: offers a potential planning approach to investigate and manage cumulative environmental problems. Weakness: application in CEA would be a novel departure from typical socioeconomic applications.

Table 5.6 (continued):

Land suitability evaluation (e.g., "Land disturbance target"): The essence of this method is to select an indicator of environmental quality and to establish an allowable target or threshold for this indicator, which is then used as a decision criteria to evaluate the cumulative effects of existing and future developments within an area. Strength: particularly suitable as a planning tool to evaluate and manage cumulative effects at the local and regional levels. Weakness: only a single activity or sole indicator of environmental change (e.g., erodibility); data-requirements dependent on a time limited historical record; an assumption that past land use trends and environmental responses are continued into the future.
Process guidelines: One approach consists of three main steps: Step one involves a decision tree diagram beginning with a series of directional questions to establish whether a CEA is needed for a particular problem. Major considerations include the type, size and number of projects, and spatial and temporal scales of anticipated effects. Step two requires a decision between two possible approaches to the analysis of cumulative effects, depending on the type identified in step one. Ex ante analysis is applied to identify and analyze cumulative environmental change in the future. Post analysis is implemented when cumulative effects are currently observable, but causality and origin are not known. Step three involves evaluation of development scenarios, assessment of the acceptability of future states of the environment, and appraisal of management options. Interdisciplinary expertise, "affected publics" and workshops are an inherent part of this step. Strength: satisfactorily meets most relevant CEA criteria; suited as an organizing framework within which to carry out a comprehensive CEA, including the selection and application of more rigorous methods and techniques. Weakness: lacks specificity.

Table 5.7: Primary and Special Methods for Analyzing Cumulative Effects (Council on Environmental Quality, 1997a)

Primary Methods	Description	Strengths	Weaknesses
1. Questionnaires, Interviews, and Panels	Questionnaires, interviews, and panels are useful for gathering the wide range of information on multiple actions and resources needed to address cumulative effects. Brainstorming sessions, interviews with knowledgeable individuals, and group consensus building activities can help identify the important cumulative effects issues in the region.	●Flexible ●Can deal with subjective information	●Cannot quantify ●Comparison of alternatives is subjective
2. Checklists	Checklists help identify potential cumulative effects by providing a list of common or likely effects and juxtaposing multiple actions and resources. Checklists are potentially dangerous for the analyst that uses them as a shortcut to thorough scoping and conceptualization of cumulative effects problems.	●Systematic ●Concise	●Can be inflexible ●Do not address interactions or cause-effect relationships
3. Matrices	Matrices use the familiar tabular format to organize and quantify the interactions between human activities and resources of concern. Once even relatively complex numerical data are obtained, matrices are well-suited to combining the values in individual cells in the matrix (through matrix algebra) to evaluate the cumulative effects of multiple actions on individual resources, ecosystems, and human communities.	●Comprehensive presentation ●Comparison of alternatives ●Address multiple projects	●Do not address space or time ●Can be cumbersome ●Do not address cause-effect relationships
4. Networks and System Diagrams	Networks and system diagrams are an excellent method for delineating the cause-and-effect relationships resulting in cumulative effects. They allow the user to analyze the multiple, subsidiary effects of various actions, and trace indirect effects to resources that accumulate from direct impacts on other resources.	●Facilitate conceptualization ●Addresses cause-effect relationships ●Identify indirect effects	●No likelihood for secondary effects ●Problem of comparable units ●Do not address space or time
5. Modeling	Modeling is a powerful technique for quantifying the cause-and-effect relationships leading to cumulative effects. Modeling can take the form of mathematical equations describing cumulative processes such as soil erosion, or may constitute an expert system that computes the effect of various project scenarios based on a program of logical decisions.	●Can give unequivocal results ●Addresses cause-effect relationships ●Quantification ●Can integrate time and space	●Need a lot of data ●Can be expensive ●Intractable with many interactions
6. Trends Analysis	Trends analysis assesses the status of a resource, ecosystem, and human community over time and usually results in a graphical projection of past or future conditions. Changes in the occurrence or intensity of stressors over the same time period can also be determined. Trends can help the analyst identify cumulative effects problems, establish appropriate environmental baselines, or project future cumulative effects.	●Addresses accumulation over time ●Problem identification ●Baseline determination	●Need a lot of data in relevant system ●Extrapolation of system thresholds is still largely subjective

Table 5.7 (continued):

Primary and Special Methods	Description	Strengths	Weaknesses
7. Overlay Mapping and GIS	Overlay mapping and geographic information systems (GIS) incorporate locational information into cumulative effects analysis and help set the boundaries of the analysis, analyze landscape parameters, and identify areas where effects will be the greatest. Map overlays can be based on either the accumulation of stresses in certain areas or on the suitability of each land unit for development.	●Addresses spatial pattern and proximity of effects ●Effective visual presentation ●Can optimize development options	●Limited to effects based on location ●Do not explicitly address indirect effects ●Difficult to address magnitude of effects
8. Carrying Capacity Analysis	Carrying capacity analysis identifies thresholds (as constraints on development) and provides mechanisms to monitor the incremental use of unused capacity. Carrying capacity in the ecological context is defined as the threshold of stress below which populations and ecosystem functions can be sustained. In the social context, the carrying capacity of a region is measured by the level of services (including ecological services) desired by the populace.	●True measure of cumulative effects against threshold ●Addresses impact in system context ●Addresses time factors	●Rarely can measure capacity ●May be multiple thresholds ●Requisite regional data are often absent
9. Ecosystem Analysis	Ecosystem analysis explicitly addresses biodiversity and ecosystem sustainability. The ecosystem approach uses natural boundaries (such as watersheds and ecoregions) and applies new ecological indicators (such as indices of biotic integrity and landscape pattern). Ecosystem analysis entails the broad regional perspective and holistic thinking that are required for successful cumulative effects analysis.	●Uses regional scale and full range of components and interactions ●Addresses space and time ●Addresses ecosystem sustainability	●Limited to natural systems ●Often requires species surrogates for system ●Data intensive ●Landscape indicators still under development

Table 5.7: (continued):

Special Methods	Description	Strengths	Weaknesses
10. Economic Impact Analysis	Economic impact analysis is an important component of analyzing cumulative effects, because the economic well-being of a local community depends on many different actions. The three primary steps in conducting an economic impact analysis are (1) establishing the region of influence, (2) modeling the economic impacts, and (3) determining the significance of the impacts. Economic models play an important role in these impact assessments and range from simple to sophisticated.	• Addresses economic issues • Models provide definitive, quantified results	• Utility and accuracy of results dependent on data quality and model assumptions • Usually do not address nonmarket values
11. Social impact Analysis	Social impact analysis addresses cumulative effects related to the sustainability of human communities by (1) focusing on key social variables such as population characteristics, community and institutional structures, political and social resources, individual and family changes, and community resources; and (2) projecting future effects using social analysis techniques such as linear trend projections, population multiplier methods, scenarios, expert testimony, and simulation modeling.	• Addresses social issues • Models provide definitive, quantified results	• Utility and accuracy of results dependent on data quality and model assumptions • Social values are highly variable

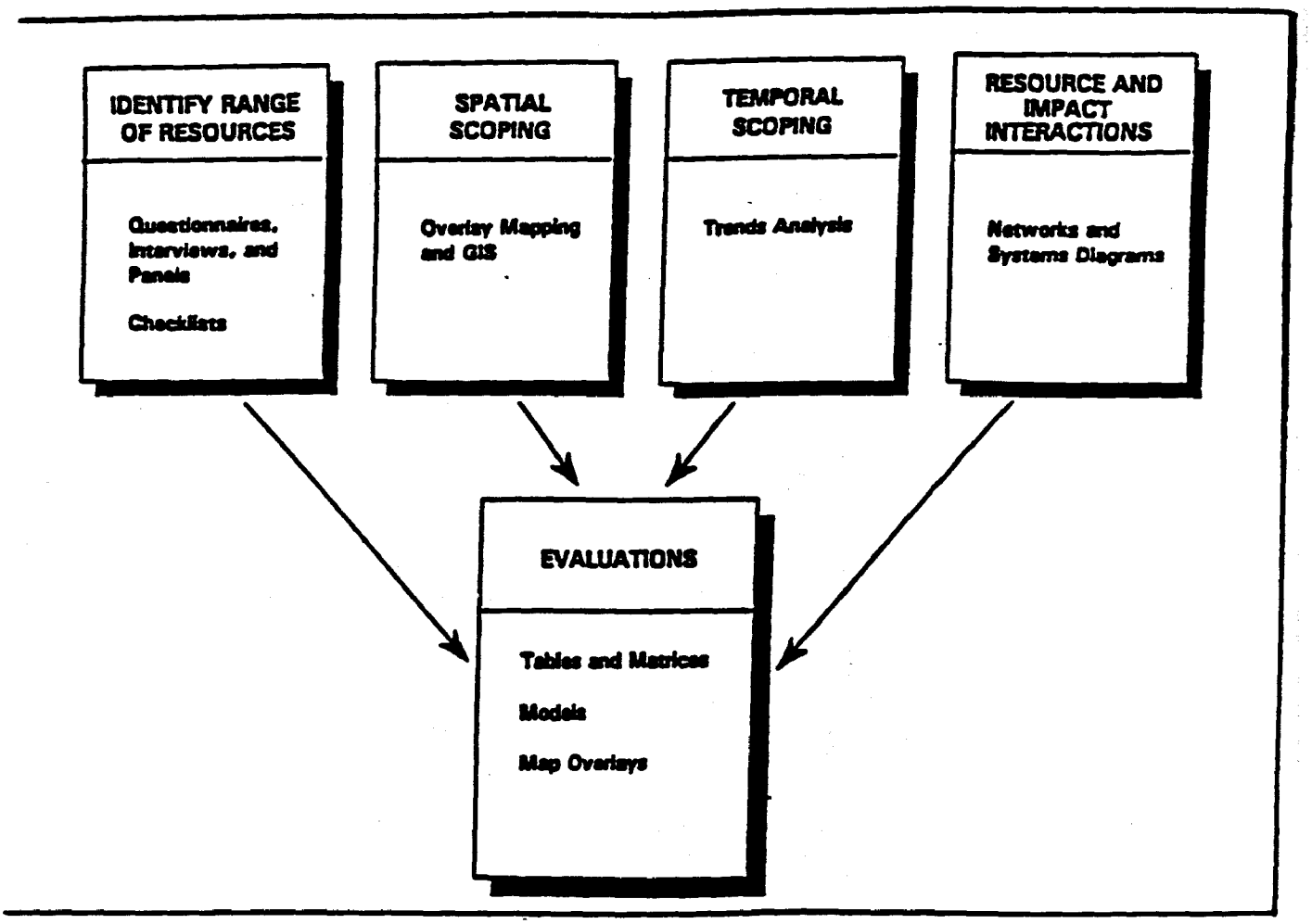


Figure 5.1: Conceptual Model for Combining Primary Methods in a CEA (Council on Environmental Quality, 1997a)

socio-economic), or indications of focus (guidelines for CEA process or methods for usage within the process). Such delineations would aid in the development of appropriate comparisons between methods.

(4) The reviewed methods are often listed without examples of their application in CEA studies. Thus it may not be possible to judge between actual versus potential applications of the methods.

(5) As is the case for EIA methods, there is no single CEA method that meets all of the desirable criteria for such methods, nor can a CEA study depend on one method for meeting all study needs. Accordingly, a CEA study should typically involve the use of several types of methods for different purposes. Based on the assumption that selection of methods, either formally or informally, is a component of every CEA study, the question then becomes targeted on what approaches might be used to accomplish such selections. Examples include: (1) an approach based upon professional judgment only; (2) an approach based upon systematic but qualitative comparisons of different methods for usage for different purposes; and (3) an approach involving quantitative comparisons of different methods arrayed against a series of weighted decision criteria (factors).

EXAMPLES OF CEA METHODS

Methodologies which have actually been used in CEA include checklists, matrices, nodal networks or pathways, qualitative dynamic models to simulate ecosystem response, cartographic (or mapping) techniques, and adaptive or ad hoc methods which combine several types of methods (Vestal, et al., 1995). Other types of methods include spatial analysis, ecological modeling, monitoring, and expert opinion (Barrow, 1997). Accordingly, this listing is mainly focused on methodologies for identifying cumulative effects. Further, dynamic models can be qualitative (or descriptive) or quantitative in focus, with the latter type useful for quantifying potential cumulative effects.

One type of method which has been used for over 25 years in EIA practice is the "questionnaire checklist." Such checklists generally include upwards of 100 questions focused upon categorized impacts; i.e., the user answers questions (by yes, no, or need more information) which are generally formatted in terms of "does the proposed action have the potential for causing an impact on environmental factor (or resource) 1,2 etc.?" Specific questionnaire checklists have been developed by project type (e.g., hydroelectric), by topical issue (e.g., human health impacts,) and/or by agency responsibility (e.g., U.S. Department of Energy). Traditional EIA-related questionnaire checklists typically focus on the impacts of the proposed action. Questionnaire checklists for CEA would need to broaden the issues addressed to encompass impacts associated with the operable cumulative effects definition.

An example of broadened CEA-related checklist containing about 100 questions organized into 21 categories is included in Canter and Kamath (1995). The 21 topical categories include physical components (landform, air/climatology, water, solid waste, noise, and hazardous waste), biological components (flora and fauna), and socioeconomic components (land use, recreation, aesthetics, archaeological sites, health and safety, cultural patterns, local services, public utilities, population, economic factors, transportation, natural resources, and energy). The

user first answers questions regarding the impacts of the proposed action on specific features of the categories; for example, the features within air/climatology include air quality changes due to gases, particulates, and fugitive dust; exceedance of emission standards; objectional odors; climate variations due to changes in humidity, air movement, or temperature; emissions of hazardous air pollutants; and acid rain. The same series of questions are then considered regarding the cumulative effects of the proposed action and past, present, and reasonable foreseeable actions.

Questionnaire checklists can be useful during the scoping process to identify cumulative effects of concern. The impact study team discussion can become more focused on the key cumulative effects and for documenting how they were selected for subsequent technical analyses. As such CEA checklists become more refined and standardized, they will provide a valid tool (method) which can be used to consistently identify anticipated cumulative effects. Further, they can be easily adapted to meet the cumulative effects identification needs of a particular EIA study. Such checklists can also be incorporated into personal computers to facilitate ease of usage, thus providing the basis for the future development of more sophisticated expert systems. Because questionnaire checklists are directed to impact identification, other methods would be needed to quantify cumulative effects, to incorporate their consideration in trade-off analyses of alternatives, and to develop appropriate mitigation measures (Canter, 1997).

Table 5.8 displays a simple interaction matrix depicting the fish and wildlife effects of small hydropower projects (less than 10 MW) in the Columbia River Basin in the USA along with similar effects which can occur from nonhydropower activities in the Basin (Stull, et al., 1987a).

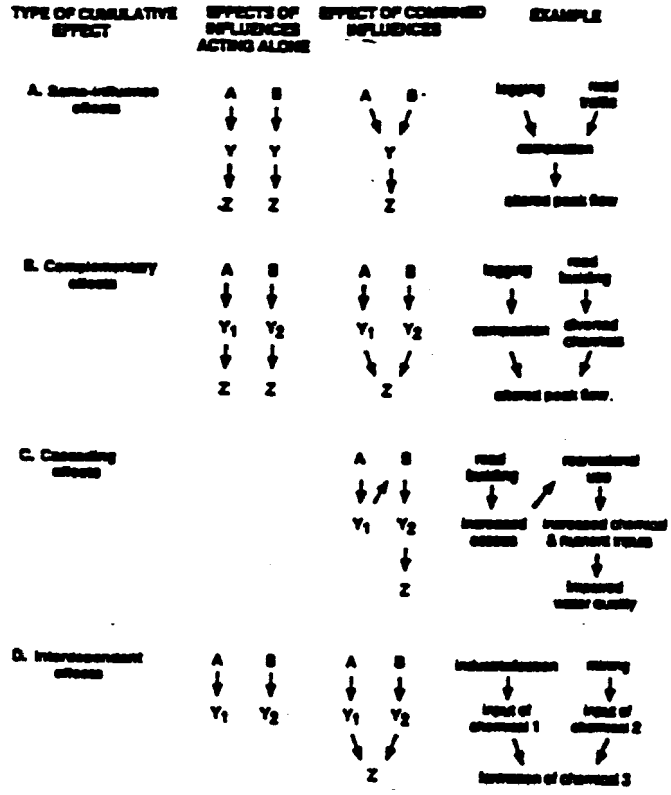
Watershed-based approaches for environmental planning and management have been increasing in the United States. Accordingly, such geographical areas can be useful in establishing CEA spatial boundaries relative to changes in surface water quantity and quality. Illustrations of some types of cumulative effects, from a watershed perspective, are shown in Figure 5.2 (Reid, 1993). The displayed typology can be useful in identifying cumulative effects from multiple activities within a watershed. The simple interaction matrices in Tables 5.9 and 5.10 display direct effects of activities on watershed properties, and in turn, on watershed processes, respectively (Reid, 1993). These tables can be useful in scoping and the identification of potential cumulative biophysical effects. The implications of process changes on aquatic ecosystems are not displayed in Table 5.10.

The concept of a stepped matrix which was used in a CEA study of open cut mining of black coal in Australia is in Figure 5.3 (Court, Wright, and Guthrie, 1994). The "activities" include multiple projects, or the multiple parts of a single project, which can cause cumulative effects. In this specific case, the activities included fuel burning and metal smelting, irrigated grape vineyards, transport, and coal mining. Environmental indicators for the study area included fine particles, sulfur dioxide, overburden chemical composition, and agricultural chemicals; and the valued environmental components included air quality health criteria, irrigation-quality water, species diversity, and visual amenity.

A cause-effect network for identifying the cumulative effects of coastal zone development projects in Australia is in Figure 5.4 (Court, Wright, and Guthrie, 1994). This network displays relationships between causes of environmental change, resultant perturbations, and primary and secondary impacts.

Table 5.8: Effects of Hydropower on Fish and Wildlife that Also Occur from Other Activities in the Columbia River Basin (Stull, et al., 1987a).

Hydropower Effects	Nonhydropower Activities								
	Agricultural	Fishery	Mining	Recreational	Residential/ Industrial	Road Construction	Timber Harvest	Waste Disposal	Water Supply
FISHERIES									
Sedimentation and Erosion	●		●	●	●	●	●	●	●
Disturbance of Hazardous Waste Sinks	●		●		●			●	
Interference with Fish Migration	●						●		●
Altered Stream Flow	●		●	●	●		●		●
Disruption of Food Production and Transport	●		●	●	●		●		●
Inundation of Stream Habitats	●								●
Fishing Area, Opportunity, and Catch	●	●	●	●	●	●	●	●	●
Changes in Water Quality	●		●	●	●	●	●	●	●
Overharvest of Wild Stocks in a Mixed-Stock Fishery	●	●							
WILDLIFE									
Increased Human Access and Disturbance	●	●	●	●	●	●	●		●
Reduction of Aquatic Prey	●	●	●	●	●	●	●	●	●
Loss of Critical Terrestrial Wildlife Habitats	●		●	●	●	●	●	●	●
Loss of Stream Habitats and Creation of Open-Water Habitats	●								●
Interruption of Movement and Migration	●		●		●	●	●		●
Bird Mortality at Transmission Lines	●				●				
Degradation of Shoreline Habitats	●		●	●	●	●	●	●	●



Note: A and B are activities, Y is an environmental parameter, and Z is an impact.

Figure 5.2: Combinations of Activities that Can Cause Cumulative Effects in Watersheds (Reid, 1993)

Table 5.9: Potential Direct Effects of Selected Land-Use Activities on Watershed Properties (Reid, 1993)

Activity	Auxiliary use BCILRV	Vegetation CDP	Soil DS	Topography CFMNS	Chemicals INR	Other FHPW
Construction	...LR.	C.P	DS	CFMNS	I.R	F...
Impoundments	.C..R.	CDP	..	CF.N.	I..	F..W
Channelization	.C..R.	CD.	..	CFMN.	...	....
Road use and maintenance	.C.L..	C..	.S	CFMN.	I..	..P.
Vegetation conversion	B.....	C.P	DS	..M..	INR	F.P.
Burning	.....	CDP	.S	..M..	..R	FH..
Water development						
Transbasin imports	.CILR.	.D.	..	...N.	I..	F.PW
Groundwater	.....	...	..	.....	I..	...W
Timber management						
Logging and yarding	.C..R.	CDP	DS	C.MN.	I.R	F...
Planting and regeneration	B....V	...	..	.....	...	....
Pest and brush control	B.....	C..	..	.....	I..	F.P.
Fire control	BC..R.	CDP	..	..M..	...	....
Range use - grazing	B.I.RV	CDP	.S	C.M..	.N.	F.PW
Mining						
Open pit mining	.C..R.	C.P	D.	CFMNS	I.R	F...
Underground mining	.C..R.	...		.F...	I..	....
Placer gold and gravel	.C.LR.	CDP	D.	CFMNS	I.R	F...
Tailings storage	....R.	CDP	DS	CFMNS	I..	F...
Mine reclamation	....RV	...	.S	CFMN.	...	....
Agriculture						
Tillage and cropping	....RV	.D.	.S	..MN.	..R	F.P.
Irrigation	..ILR.	...	..	...N.	I..	...W
Insect and weed control	B.....	C..	.S	..M..	I..	F.P.
Urbanization and power						
Habitation	.CILR.	..P	.S	..M..	IN.	FHPW
Industry	.CILR.	..P	.S	..MN.	I..	.H.W
Power plants	.CILR.	...	..	.....	I..	.H.W
Recreation and fishing						
ORVs	....R.	C..	.S	C.MN.	I..	....
Trails	.C....	C..	.S	C.MN.	...	....
Camping	.C..R.	C..	.S	C.M..	IN.	..P.
Fishing and hunting	....R.	...	..	.....	I..	F...

Auxiliary use
- B Burning
- C Construction
- I Impoundments
- L Channelization
- R Road use/maintenance
- V Vegetation conversion

Vegetation
- C Community composition
- D Disturbance frequency
- P Pattern of communities

Soils
- D Disruption of horizons
- S Altered soil structure

Topography
- C Channel/bank morphology
- F Emplacement of fill
- M Altered microtopography
- N Altered channel network
- S Oversteepening of slopes

Chemicals
- I Non-nutrient chemical input
- N Introduction of nutrients
- R Removal of nutrients/organics

Other
- F Faunal introduction/removal
- H Introduction of heat
- P Introduction of pathogens
- W Import/removal of water

Table 5.10: **Effects of Altered Environmental Parameters on Watershed Processes (Reid, 1993)**

	Runoff PIEMHCY	Sediment AHCBY	Organics ADHRCBY	Chemicals AHCBY	Heat AW
Vegetation					
C Altered community composition	P.E.H..	.HC..	A.H..B.	A....	AW
D Altered disturbance frequency	.....	.H...	A....B.	.....	..
P Altered pattern of communities	.....	.....	.....	.....	..
Soils					
D Disruption of horizons	.....	A....	.....	A....	..
S Altered soil structure	.I.....	.H...	.....	.....	..
Topography					
C Altered channel/bank morphology	.....C.	..C..	....C..	.....	.W
F Emplacement of fill	.....	A..B.	.....	.....	..
M Altered microtopography	....H..	.H...	..H....	.....	..
N Altered channel network	.....C.	..C..	....C..	.....	.W
S Oversteepening of slopes	....H..	.H...	..H....	.....	..
Chemicals and nutrients					
I Import of non-nutrient chemicals	.....	.....	.....	A..B.	..
N Introduction of nutrients	.....	.....	.....	A..B.	..
R Removal of nutrients or organics	.....	.....	A.....	.....	..
Other effects					
F Introduction or removal of fauna	.....	.HC..	A.....	.....	..
H Introduction of heat	.....	.....	.....	.....	AW
P Introduction of pathogens	.....	.....	.....	.....	..
W Import or removal of water	P....CY	.....	.....	...B.	.W

Runoff
- P Production process
- I Infiltration
- E Evapotranspiration
- M Soil moisture
- H Hillslope hydrograph
- C Channel hydrograph
- Y Annual water yield

Sediment
- A Amount and character on hills
- H Hill erosion process and rate
- C Channel erosion process and rate
- B Amount and character in channel
- Y Sediment yield and character

Organic material
- A Amount and character on hills
- D Decay rate on hillslopes
- H Transport rate on hillslopes
- R Decay rate in channel
- C Transport rate in channel
- B Amount and character in channel
- Y Volume and character exported

Chemicals
- A Soil chemistry
- H Transport on hillslopes
- C Transport in channel
- B River chemistry
- Y Volume and character exported

Heat
- A Air temperature
- W Water temperature

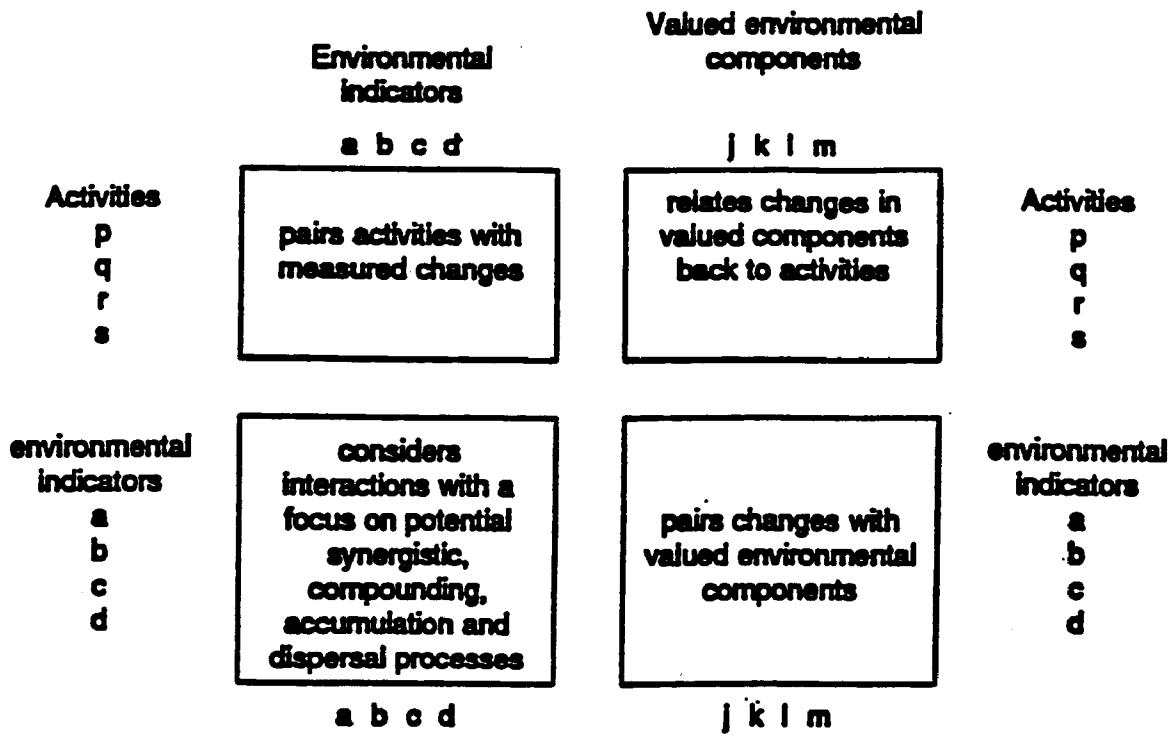


Figure 5.3: Concept of Stepped Matrix Used for Open Cut Mining of Black Coal in Australia (Court, Wright, and Guthrie, 1994)

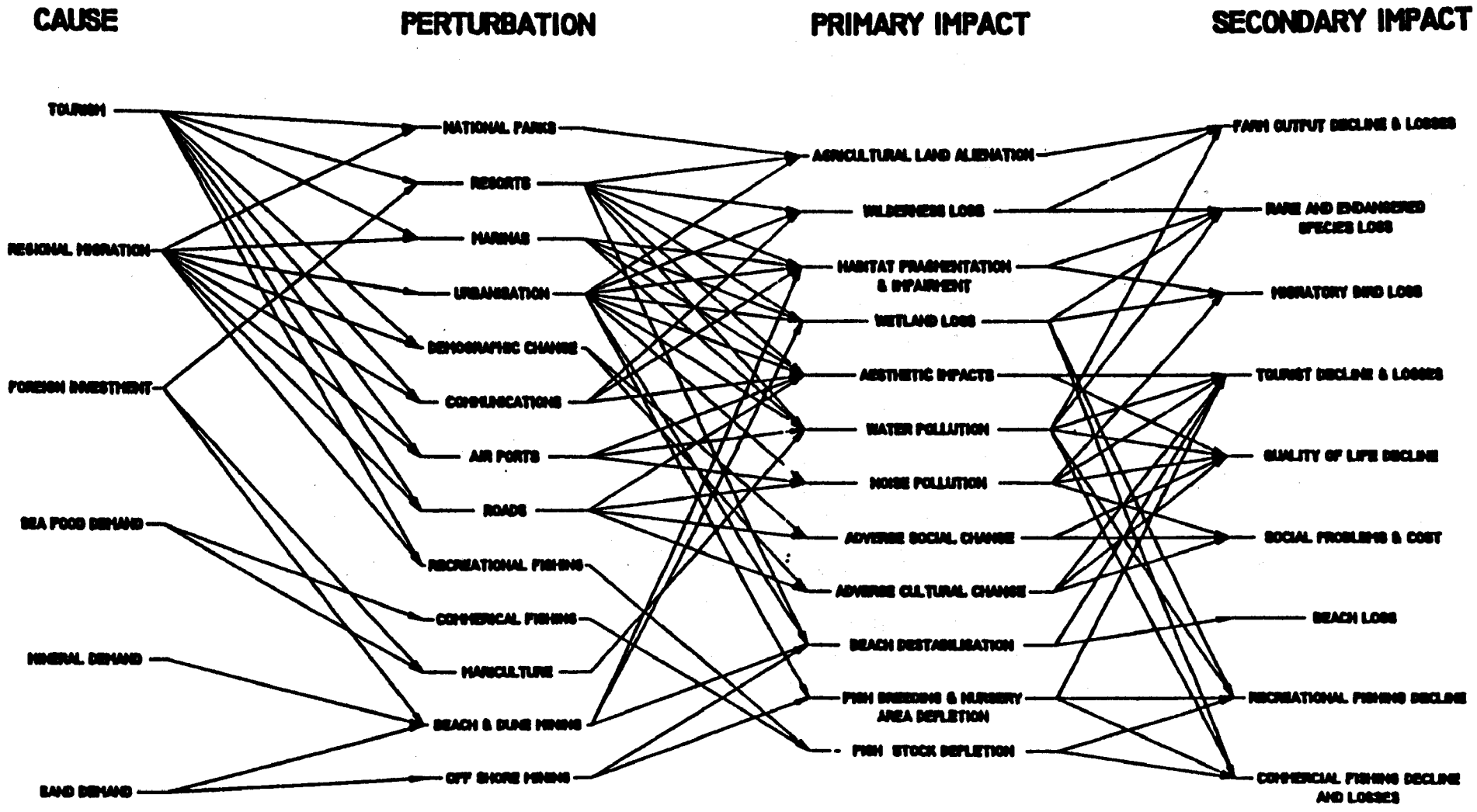


Figure 5.4: Cause-Effect Network for Development Projects in the Coastal Zone of Australia (Court, Wright, and Guthrie, 1994)

Finally, modifications of EIA methods have been used in CEA; for example, via matrix methods, causal analysis, and adaptive management (Sonntag, et al., 1987). Matrix methods have been developed to incorporate effects ratings and factor importance in a manner to facilitate the calculation of cumulative effects as the sum of all project-specific effects adjusted for interactions among projects in the study area. Causal analysis involves a "backstop analysis" wherein cumulative effects are traced back to specific activities and then reconfigured into a cause-effect network. Such networks can provide the basis for the development of effects hypotheses and appropriate quantitative models. The adaptive environmental assessment and management (AEAM) method was developed for EIA, and with the use of focused workshops and simulation modeling, the concepts can be extended to CEA.

SELECTION APPROACHES FOR CEA METHODS

A typical impact study requires the selection of one or more methods to meet identified study needs. Accordingly, consideration needs to be given to certain approaches which could be used in such a selection process. For some impact studies, the sponsoring agency (proponent) may specify the methods to be used. Depending upon the type of study, such methods may be dictated by proponent best practices or by statutory requirements. At the other extreme, and perhaps more typical of impact studies, is when the proponent does not specify any methods for usage with the presumption being that the professionals on the interdisciplinary team conducting the study will utilize appropriate methods depending upon the type of project, environmental setting, and study parameters such as time and funding. All impact studies require some methods selection, including those studies that have stipulations for the usage of particular methods due to statutory requirements. For example, it may be necessary to select one or methods for impact identification related to a proposed coal-fired power plant, but then to utilize a specified air quality dispersion model for addressing the atmospheric dispersion of sulfur dioxide from the plant stacks.

Based on the assumption that selection of methods, either formally or informally, is a component of every impact study, the question then becomes targeted on what approaches might be used to accomplish such selections. Three such approaches are considered herein: (1) an approach based upon professional judgment only; (2) an approach based upon systematic but qualitative comparisons of different methods for usage for different purposes; and (3) an approach involving quantitative comparisons of different methods arrayed against a series of weighted decision criteria (factors).

Use of Professional Judgment Approach

Method selection based upon professional judgment is actually involved in all three approaches, with the distinction in this first approach being that methods are chosen based upon the professional knowledge and judgment of individuals on an interdisciplinary study team, or the collective judgment of the study team as a whole, regarding comparative features of available methods and their usage in the pertinent impact study. In this regard, specific decision criteria for comparing methods may not be delineated, with choices probably being related to the familiarity and possible previous usage of methods by individuals on the team. It is important to note that professional judgment can relate to both substantive issues addressed by individual methods as well as their comparative ease of usage in terms of required data, time considerations, and budgetary limitations.

Use of Qualitative Comparison Approach

When methods are selected based on qualitative comparisons, these selections are typically made based on identifying decision criteria (or desirable attributes) and then comparing candidate methods, possibly on a relative basis, in conjunction with each of the listed criteria (or attributes). Several examples for this selection approach have been published, with the typical process involving:

(1) the identification of decision criteria (desirable attributes) for methods;

(2) the qualitative comparison of candidate methods relative to the desirable attributes; and

(3) the selection of the "best choice" for the situation based on the information in (2) coupled with professional judgment.

Four examples of desirable attributes (or decision criteria) will be cited; one is related to decision-focused checklists, one to methods in general, and the latter two to impact prediction methods. Multi-criteria decision-making methods, or decision-focused checklists, have been referred to as amalgamation methods by Hobbs (1985). Such amalgamation involves combining disparate impacts so that alternatives can be ranked. Hobbs (1985) suggested four criteria for consideration in choosing an amalgamation method; these criteria were: (1) the purpose to be served, (2) the ease of use (time, money, necessary computer resources, etc.), (3) the validity of the method, and (4) the anticipated results when compared to other methods.

Nichols and Hyman (1982) identified seven criteria for evaluating EIA methods in general, and Table 5.11 summarizes these criteria. The first three reflect the complex attributes of real environmental responses to natural or man-induced changes. The remaining four represent the preferable attributes of a planning and decision-making process.

Decision factors related to the selection of impact prediction methods were enumerated by Environmental Resources, Ltd. (1982) following an extensive review of such methods. Key decision factors expressed in the form of questions are included in Table 5.12 (after Environmental Resources, Ltd., 1982).

A second example of decision criteria for impact prediction methods includes eight criteria as shown in Table 5.13. These criteria include both practical and technical considerations. On the practical side, the method must first be credible, including: (1) substantive relevancy to the proposed action; (2) policy relevancy in terms of providing useful actionable information; (3) acceptability to affected publics; and (4) face validity to relevant experts or professionals. If the method is credible, additional desirable characteristics include how easily it can be used (applicability) and whether it can be used for different conditions and geographic areas (flexibility). Technical criteria include both accuracy and completeness. Methods should be able to provide results within acceptable error ranges, and they should provide a relatively comprehensive picture of impacts.

Impact prediction methods which could be compared relative to the questions in Tables 5.12 or 5.13 could be "off-the shelf" methods, or they could require modification to meet the particular impact study needs. Depending upon the particular needs, it may be necessary to develop

Table 5.11: Criteria for Evaluating EIA Methodologies
(Nichols and Hyman, 1982)

1. Assessment methods should recognize the probabilistic nature of effects. Environmental cause-effect chains are rarely deterministic because of many random factors and uncertain links between conditional human activities and states of nature.

2. Cumulative and indirect effects are important, although there are obviously limits on the extent to which they can be considered. Natural systems are highly interrelated, and a series of minor actions may have significant cumulative impact. Indirect effects may be cyclical due to positive or negative feedback.

3. A good methodology should reflect dynamic environmental effects through a capacity to distinguish between short-term and long-term effects. Impacts may vary over time in direction, magnitude, or rates of change. The larger system itself may be in ecological or social flux, and decisionmakers have time horizons of varying lengths.

4. Decision making necessarily encompasses multiple objectives (or multiple values). Assessment methods should include the diverse elements of environmental quality: maintenance of ecosystems and resource productivity; human health and safety; amenities and aesthetics; and historical and cultural resources. Environmental values can be divided into three types: social norms, functional values (environmental services, e.g., fisheries), and individual preferences. In addition, a good assessment method should recognize other societal objectives, such as economic efficiency, equity to individuals and regions, and social well-being.

5. Environmental assessment necessarily involves both facts and values. Values enter the process when deciding which effects to examine, whether an effect is good or bad, and how important it is relative to other effects. Methods should separate facts and values to the extent possible, and identify explicitly the source of values. Where the influence of values is obscure, the analysis itself may become a source of conflict. Under optimal conditions, results should be amenable to a sensitivity analysis where alternative value judgments are applied to a set of factors.

6. It is also important to consider whose values enter the analysis. Assessment techniques should encourage a participatory approach to incorporate the multiplicity of values provided by the public as well as by experts from varying disciplines and interest groups. Lack of participation by key actors can mitigate the usefulness of assessment results.

7. With all other things held constant, the best decision process is efficient in its requirements for time, money, and skilled labor. Increased complexity is justified only when there is a sufficient increase in the validity and decision-making utility of the analytical results.

Table 5.12: Questions Related to Evaluating and Selecting Impact Prediction Methods (after Environmental Resources, Ltd., 1982)

(1)	Can the method be used to produce the information needed? If not, can it be adapted to produce this information?
(2)	Can the method be applied to the particular activity and environment under study (i.e., to the alternative activities and environments which must be compared)? Are the limitations of the method, and the assumptions made, applicable to the circumstances of the proposed alternatives and the affected environments?
(3)	Are the data needed to use the method available? If not, can they be collected using the available resources of time, manpower, equipment, etc.?
(4)	Are the resources available to use the method - computing time, laboratory work, field studies, expertise, etc.?
(5)	Are the outputs from the method in a suitable form to serve as inputs into predictions of higher order effects if necessary?
(6)	Can the outputs from the method be presented in a form which is understandable and useful for the decision maker and other users? What will be the costs of analyzing and interpreting the results for the end users?
(7)	Can the method be satisfactorily explained to the non-specialist so that he/she can understand its use, and does it generate information in a form comprehensible to a broad range of people with different backgrounds?
(8)	Does the method provide a sufficiently accurate or reliable prediction of the effect? What is the level of uncertainty associated with the prediction?
(9)	If the method was repeated using the same data base would a second group obtain the same result as the first group?

Table 5.13: Criteria for Choosing Impact Prediction Methods

Criteria	Definition
I. Practicality	
1. Substantive relevancy	Appropriateness for the proposed action. Previous use to assess impacts of similar proposed actions is one indicator of relevancy.
2. Policy relevancy	Does the method provide information which can be useful, particularly with respect to avoiding or mitigating impacts? Methods would need to address actionable impact categories, be capable of producing timely predictions, etc.
3. Acceptability	Is the method acceptable to relevant publics likely to be impacted? Does it include the substantive areas of concern to local populations? These areas of concern can be determined by previous experience, public hearings, or survey techniques.
4. Face validity	Is the method credible in the professional research community or with others having experience in assessing similar types of impacts? This can be determined by the use of advisory groups or external review panels.
5. Applicability	Ease of using or implementing this method. Do the data exist; are analysis routines easy to use, etc.? Must be determined by professional judgment.
6. Flexibility	Can the method be used for different substantive impact areas, for different geographic areas, different environmental conditions, etc.?
II. Technical Quality	
7. Accuracy	Is the method likely to provide results within acceptable error ranges? Has it been subject to previous reliability and validity studies? Has it generated significant problems in previous uses?
8. Completeness	Does the method include a complete set of impacts? Can it be easily combined with other approaches to provide a comprehensive picture?

specific models or methods for impact prediction. The time and associated costs for modification or development should be considered in the selection process.

Finally, the following points related to selecting impact prediction methods using a qualitative comparison approach should be remembered (Environmental Resources, Ltd., 1982):

(1) The selection of appropriate methods for use in EIA is always a balance between the need for information and the availability of resources; to obtain a more accurate and complete description of an effect always requires the expenditure of more resources.

(2) The selection of methods for obtaining information about environmental effects involves:

- identifying methods which can provide the types of information needed;
- and examining whether they are applicable to the particular activity and environment in question, and with the resources available for the impact study.

(3) Many methods can be used at varying levels of sophistication. Their applicability in different circumstances and their resource requirements will vary accordingly, with a corresponding variation in the quality of information obtained.

(4) Where limited resources are available, decisions have to be made about information needs for different effects, and therefore about the allocation of these resources between the different effects.

(5) Each specialist will have his own "favorite" method for solving a problem, which is only natural for him/her to advocate. The overall impact study group (interdisciplinary team) needs to maintain a wider view of the needs and possibilities and thus advise the specialist accordingly.

(6) Occasionally a method specifically designed for the study area (but for some other purpose) is available for use, already calibrated and validated; if it can be adapted to serve the impact study needs it may provide an extensive predictive capacity with small use of resources.

(7) In certain cases only one method is available to predict a particular type of effect for a particular type of environment; information needs must then be conditioned to match the possible outputs from that method. But the problem should not be redefined solely to suit the method.

(8) Often there may be no one method which is suitable; the results of several may then be combined together to give the fullest possible picture of the environmental effect. Additional methods may also be used to test the results of a first method.

(9) The choice of methods is not immutable; adaption, evolution and shifting of approaches can be expected as an impact study proceeds and understanding is improved.

Use of Unranked Pairwise Comparison Approach

The most comprehensive approach relative to selecting methods would involve utilizing a systematic comparison of methods relative to pre-selected decision criteria (factors), with consideration given to the relative importance of the decision criteria and to the comparative features of each method in conjunction with the stated criteria. In this regard, such approaches are analogous to multiple criteria decision making which has been used for comparison of alternatives in environmental impact studies. To illustrate the pragmatic nature of this approach for such decision making, the following steps can be identified:

(1) The first step would involve specifying the particular phase of the impact study for which a method should be selected, and then identifying key decision factors or desirable attributes which should be considered in selecting the method.

(2) Consideration should then be given to the relative importance of the decision factors and to the usage of importance weighting to indicate the differential importance of the decision factors in selecting the method.

(3) Each candidate method should be compared on some type of relative basis in association with each decision factor. The information related to each decision factor could be either qualitative or quantitative, with the resulting comparisons of the candidate methods being an approach which would reduce the information to a common perspective or common scale.

(4) A final decision matrix can be developed, using a mathematical approach, by multiplying the importance weight of each decision factor times the numerical score of each candidate method for the individual factor. When these are summed across the candidate method, the following selection score would result:

$$Score_j = \sum_{i=1}^{n} (FIC)_i \, (RCC)_{ij}$$

where

$Score_j$ = composite selection score for the jth candidate method

n = number of decision factors

$(FIC)_i$ = importance coefficient of the ith decision factor

$(RCC)_{ij}$ = relative choice coefficient of the ith decision factor for the jth candidate method

To illustrate this approach, an unranked pairwise comparison technique will be utilized to indicate how it could be applied in selecting a method for accomplishing a particular need within an impact study.

The first step in using the unranked pairwise comparison technique is to list the decision factors (criteria) and assemble information on each considered method relative to each factor. Table 5.14 shows the results for this illustration. The decision factors in Table 5.14 can be prioritized based on their relative importance. This is called importance

Table 5.14: Example Information for Selecting an EIA Method

Decision Factor	Candidate EIA Methods			
	A	B	C	D (dummy)
Acceptability by EIA regulators	Acceptable	Not acceptable without modification	Some effort required to gain acceptability	Not acceptable
Data requirements for use of method	Moderate	Minimal	Moderate	Extensive
Uncertainty related to method	Some uncertainty	Some uncertainty	Minimal uncertainty	High uncertainty
Dummy	-	-	-	-

weighting; it consists of considering each decision factor relative to every other factor, and assigning to the one considered to be the most important of the pair a value of 1, and to the lesser important of the pair a value of 0. This unranked paired-comparison technique, which is shown in Table 5.15, does not mean that the factor assigned a 0 in each pair has no importance; it simply means that relative to the pair, the factor is least important. In addition to the basic decision factors, a dummy factor is included so as to preclude the net assignment of a value of 0 to any one basic factor in the process. The dummy factor is defined as the least important in every comparison. If two factors are considered to be of the same importance (one is not more important than the other), a value of 0.5 can be assigned to each factor in the pair.

Following assignment of the relative weights as shown in Table 5.15, with this process only being completed following several iterations to be sure that each factor is considered in a consistent manner to each other factor, the individual weight assignments are summed, with the factor importance coefficient (FIC) being equal to the sum value for an individual factor divided by the sum for all factors. The total the FIC column should equal 1.00. The total of the sum column should equal to (N) (N-1)/2, where N is the number of factors included in the assignment of weights. In this example, four factors were included, hence the sum total should be 6.0. The assignment of importance weights can be done by an individual, or by a group of both technical and non-technical persons who are charged with the responsibility of identifying the most appropriate EIA method for a given need. The FIC column in Table 5.15 indicates that acceptability by EIA regulators is the most important followed by, in order, data requirements and uncertainty.

The next step in the decision process involves comparing each candidate method relative to each decision factor. Comparisons can be based on quantitative, qualitative, or relative information. Examples of qualitative information are included in Table 5.14. The systematic comparison of methods involves their prioritization relative to each decision factor. Table 5.16 illustrates the comparison of the methods relative to the first decision factor. Each method is compared to every other method through the use of a paired comparison approach. The basic decision for each pair of methods is to decide which one is best relative to that decision factor. For the method considered to be the best a value of 1 is assigned; to the method considered to be the least desirable of the pair a 0 is assigned. It should be noted that a dummy method is included in Table 5.16 to preclude the net assignment of a value of zero to any basic method relative to the decision factor. If two methods are the same relative to their desirability in terms of a decision factor, a value of 0.5 can be assigned to each method. Following assignment of desirability numbers to each method, the individual assignments are summed, with the relative choice coefficient (RCC) being equal to the sum value for an individual method divided by the sum for all the methods. The total for the RCC column should equal to 1.00. The total of the sum column should equal to (M) (M-1)/2, where M is the number of methods included in the analysis. In this example four methods were included, hence the sum total should be equal to 6.0. Tables 5.17 and 5.18 display the RCC values for the other decision factors in the illustration.

The final step in the use of the unranked paired-comparison decision-making technique involves the development of a decision matrix. This matrix is derived by multiplying each FIC by each RCC. Summation of the products for each alternative will yield numerical scores which can be used in the final selection. Table 5.19 illustrates the decision matrix based on the illustration. Method A would represent the optimal choice based on this decision-making approach. One numerical check in the

Table 5.15: Importance Weighting of Decision Factors

Decision Factor	Relative Importance Assignments	Sum	FIC
Acceptability by EIA regulators	1 1 1	3	0.50
Data requirements for use of method	0 1 1	2	0.33
Uncertainty related to method	0 0 1	1	0.17
Dummy	0 0 0	0	0
Totals		6.0	1.00

Table 5.16: Relative Choice Coefficients of Candidate Methods for "Acceptability by EIA Regulators" Factor

Candidate Method	Choice Assignments	Sum	RCC
A	1 1 1	3	0.50
B	0 0 1	1	0.17
C	0 1 1	2	0.33
D (dummy)	0 0 0	0	0
Totals		6.0	1.00

Table 5.17: Relative Choice Coefficients of Candidate Methods for "Data Requirements for Use of Method" Factor

Candidate Method	Choice Assignments	Sum	RCC
A	0 0.5 1	1.5	0.25
B	1 1 1	3.0	0.50
C	0.5 0 1	1.5	0.25
D (dummy)	0 0 0	0	0
Totals		6.0	1.00

Table 5.18: Relative Choice Coefficients of Candidate Methods for "Uncertainty Related to Method" Factor

Candidate Method	Choice Assignments	Sum	RCC
A	0.5 0 1	1.5	0.25
B	0.5 0 1	1.5	0.25
C	1 1 1	3.0	0.50
D (dummy)	0 0 0	0	0
Totals		6.0	1.00

Table 5.19: Decision Matrix for Selection of Method

Decision Factor	Method (FIC x RCC)			
	A	B	C	D (dummy)
Acceptability by EIA regulators	0.250	0.085	0.165	0
Data requirements for use of method	0.083	0.167	0.083	0
Uncertainty related to method	0.042	0.042	0.085	0
Dummy	0	0	0	0
SUM =	0.375	0.294	0.333	0

decision matrix is that the summation of all products for all methods should equal to 1.0.

The unranked paired-comparison multiple criteria decision-making technique is illustrative of a number of approaches which can be used to systematically compare EIA methods and select a "best choice." The primary advantage of this technique is that it provides a systematic framework for making decisions. Decisions have been, and will continue to be made without using structured approaches; however, the use of these approaches will enable decision-makers to make better choices considering all relevant selection factors. One note of caution is that careful consideration should be given to the interpretation of the FIC and RCC numerical values. These numerical values represent both quantitative information and the application of professional judgment.

In summary, the advantages of using a decision methodology in EIA methods selection include:

(1) it forces a systematic approach;

(2) it provides a rational framework;

(3) it can be used to document the selection process;

(4) it provides an "audit" trail for the selection; and

(5) it can be used to demonstrate trade-offs among the candidate methods.

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CHAPTER 6

PREDICTION METHODS FOR CUMULATIVE EFFECTS

This chapter includes a review of impact prediction methods used in the EIA process, and their applicability for cumulative effects. Further, case studies related to actual methods used are highlighted.

COMPARATIVE REVIEWS OF IMPACT PREDICTION METHODS

Impact prediction is focused on predicting changes in biophysical or socio-economic factors or resources that would or could occur as a result of a proposed project, plan, or program. The terms "predicting impacts" and "forecasting impacts" are typically considered to be synonymous. However, Culhane, Friesema, and Beecher (1987) have suggested that "forecasting impacts" is more appropriate for impact studies since: (1) predict means to foretell with the precision of calculation, knowledge, or shrewd inference from facts or experience; and (2) forecast, in contrast, suggests that conjecture rather than real insight or knowledge is apt to be involved. Thus, they suggest that the changes resulting from a project which are addressed in an EIS should be more appropriately termed as "forecasts." However, it should be noted that these definitions are not universally accepted. Therefore, the term prediction will be primarily used herein in conjunction with several comparative studies and examples of methods. Many of these studies and examples have applicability for both project-level impacts and CEA.

An early study, published in the mid-1970s, provided a comparative review of 12 techniques (methods) which could be used by water resource planners in the U.S. Army Corps of Engineers as they addressed the impacts of flood control and water supply projects (Mitchell, et al., 1975). Each method was described comparatively in terms of uses, types of results, time and personnel requirements, costs, and several other characteristics; in addition, instructions were given on procedures for applying each method, along with case illustrations. The 12 techniques included trend extrapolation, pattern identification, probabilistic forecasting, dynamic models, cross-impact analysis, KSIM, input-output analysis, policy capture techniques, scenarios and related methods, expert-opinion methods, alternative futures, and values forecasting techniques.

While this study extensively reviewed these 12 methods, they were not necessarily chosen based on their actual application in environmental impact studies. However, based on this study, and considering the potential and actual usefulness of the prediction techniques in the early 1980s, the Principles and Guidelines of the Water Resources Council in the United States delineated several prediction approaches which could be utilized in environmental planning efforts for flood control and water supply projects (Water Resources Council, 1983). These approaches included: (1) adoption of forecasts made by other agencies or groups; (2) use of scenarios based on differing assumptions regarding resources and plans; (3) use of expert group judgment via the conduction of formalized Delphi studies or the usage of the nominal group process; (4) extrapolation approaches based upon the use of trends analysis and/or simple models of environmental components; and (5) analogy and comparative analyses which involve the use of look-alike resources and/or projects and the application of information from such look-alike conditions to the

planning effort. These approaches can be applied for both biophysical and socioeconomic impact predictions.

A second study was prepared for the Ministry of Environment in The Netherlands in the early 1980s and was based on the examination of 140 environmental impact assessments (EIAs) and related studies (Environmental Resources, Ltd., 1982). The case studies encompassed a broad range of types of projects. The objectives were to identify predictive techniques actually used in the practice of EIA, prepare descriptions of the techniques, and classify the techniques in terms of the effect prediction and the method used. A total of 280 predictive techniques were identified and broadly classified into those for use in determining effects on the atmospheric environment, the surface aquatic environment, the subsurface environment (ground water and soils), the acoustic environment, plants and animals, and landscape.

Table 6.1 displays a systematic grouping of the identified prediction techniques (Environmental Resources, Ltd., 1982). Experimental methods include physical models, field experiments, and laboratory experiments focused on bioassays. Mathematical models refer to predictive techniques which use mathematical relationships between system variables to describe the way an environmental system will react to an external influence. Mathematical models can be divided into empirical or "black box" models where the relationships between inputs and outputs are established from analysis of observations in the environment; and those models which are "internally descriptive," that is, where the mathematical relationships within the model are based on some understanding of the mechanisms or processes occurring in the environment. Finally, survey techniques are based on the identification and quantification of existing or future aspects of the environmental component that might be affected in terms of its sensitivity to change or the importance of its loss or disturbance. A comprehensive discussion of these available prediction methods in relation to impacts on the atmosphere, surface water, plants and animals, landscape, soils and ground water, sound and noise, and human health and welfare was included in a subsequent composite report from the Dutch study (Environmental Resources, Ltd., 1984).

In the latter half of the 1980s, Culhane, Friesema, and Beecher (1987) reviewed 29 EISs prepared on projects in the United States in terms of the types of predicted impacts and their characteristics and associated accuracy. The sample included seven bridge and/or highway/road projects, three wastewater treatment plants and/or waste disposal projects, two airport projects, six water resources projects (small watershed, barge canal, two flood control, dredging, and dredged material disposal), three urban development projects, three park and/or forest management projects, three nuclear industry-related projects, one beach park expansion project, and one rural electric project. Based upon the study results, an ideal "model" for impact prediction was defined; the model suggests that the predictions should be quantified, their significance should be interpreted, and the related certainty/uncertainty should be specified. Table 6.2 summarizes the characteristics of the 1105 forecasts (predictions) in the sample group of 29 EISs in terms of the "ideal" EIS prediction. Obviously, the majority of the forecasts (predictions) did not match the ideal conditions.

Three categories of impact prediction methods used within the EIA process in the 1990s are shown in Table 6.3 (Canter, 1997a). This compilation was based upon the review of numerous environmental impact study documents generated in several countries (USA, Canada, The Netherlands, Australia, South Africa, and the United Kingdom). Again, the listed types of methods are intended to be representative and not all-inclusive.

Table 6.1: Systematic Grouping of Prediction Techniques (Environmental Resources Ltd., 1982)

<u>Experimental Methods</u>

(1) Physical models

- illustrative models
- 'working' models

(2) Field experiments

(3) Laboratory experiments

<u>Mathematical Models</u>

(1) Empirical models

- site-specific empirical models
- generalized empirical models

(2) 'Internally descriptive' models

- emission factor models
- roll-back models
- simple mixing models
- steady-state dispersion models
- complex mathematical models

<u>Survey Techniques</u>

(1) Inventory techniques

(2) Evaluation techniques

(3) Visibility techniques

Table 6.2: Characteristics of Forecasts That Are Closely Related to the Model of an Ideal EIS Prediction: Quantification, Significance, and Certainty (Culhane, Friesema, and Beecher, 1987)

Forecast Characteristics	Forecasts	
	N	Percent
Quantification		
Quantified		
Time-series	21	1.9
Single-number postproject value	164	14.8
Postproject values, multiple indicators	51	4.6
Bounded-values forecast	17	1.5
Percentages, re nominal classification	9	0.8
"No impact" forecast	123	11.1
Verbal, unquantified forecast	720	65.2
	1,105	100
Significance Determination		
"High" (or synonym, explicitly stated)	32	2.9
"Moderate" (or synonym, explicitly stated)	8	0.7
"Insignificant" (or synonym, explicit)	285	25.8
Quantified, without explicit significance	163	14.8
Vague/ambiguous significance statement	78	7.1
No explicit statement of significance	539	48.8
	1,105	100
Certainty/Uncertainty Addressed		
Quantified probability	1	0.1
Certainty guaranteed by situation	74	6.7
Impact conditional on intervening event	62	5.6
Probability implied by key words "will," "will not," "very likely," etc.	641	58.0
Possibility implied by key words "may," "could," "may not," etc.	318	28.8
	1,105	100

Table 6.3: Impact Prediction Techniques Currently Used in the EIA Process (Canter, 1997a)

Simple Techniques

Analogs (case studies of similar actions)

Inventory of Resources in Study Area (could use geographic information systems)

Checklists (simple, questionnaire, descriptive)

Matrices (simple, stepped) or Networks (impact trees, cause/effect or consequence diagrams)

Indices and Experimental Methods

Environmental Media Indices (air, surface and/or ground water quality or vulnerability, land or soil quality, noise)

Habitat Indices (HEP, HES) or Biological Diversity Indices

Other Indices (visual, quality of life)

Experimental Methods (laboratory, field, physical models)

Mathematical Models

Air Quality Dispersion

Hydrologic Processes

Surface and Ground Water Quality and Quantity

Noise Propagation

Expert Systems

Biological Impact (HEP, HES, WET, population, nutrients, chemical cycling, energy system diagrams)

Ecological and Health-based Risk Assessment

Archeological (predictive)

Visual Impact

Socioeconomic (population, econometric, multiplier factors)

Perhaps the simplest approach for impact prediction is to utilize analogs or comparisons to the experienced effects of existing similar projects or other types of actions. An inventory technique involves the compilation of environmental resources information for the study area through either the assemblage of existing data or the conduction of baseline monitoring, with the presumption then being that the particular resources in the existing environment, or portions thereof, will be lost as a result of the proposed action. Often-used approaches for impact prediction involve checklists or interaction matrices. Checklists range from simple listings of anticipated impacts by project type, to questionnaires incorporating a series of detailed questions related to potential impacts and environmental resources, to descriptive checklists with information on impact calculations and interpretation. Interaction matrices include simple x-y matrices to identify impacts, and stepped or cross-impact matrices for delineating secondary and tertiary consequences of proposed actions. Networks (or impact trees or chains) or cause/effect or consequence diagrams can also be utilized to trace the consequences of proposed actions. The key point relative to both checklist and matrix methods is that they yield qualitative results in terms of the predicted impacts; however, they can be useful tools when used in conjunction with environmental indices and/or quantitative modeling.

An environmental index refers to a mathematical and/or descriptive presentation of information on a series of factors which can be used for purposes of classification of environmental quality and sensitivity, and for predicting the impacts of a proposed action (Canter, 1995b). The approach for impact prediction would be to quantify, or at least qualitatively describe, the change in the index as a result of the proposed action, and to then consider the difference in the index from the with and without project (or other actions) conditions as one measure of impact. Indices exist for air quality, water quality, soil quality, noise, visual quality, land usage compatibility, and quality of life (QOL -- a socioeconomic index which can include a large number of specific factors). One type of index which has received wide usage is based on habitat considerations and the utilization of Habitat Evaluation Procedures (HEP) or the Habitat Evaluation System (HES); these techniques are primarily based on the development of a numerical index to describe habitat quality and size (U.S. Fish and Wildlife Service, 1980; and U.S. Army Corps of Engineers, 1980). Experimental methods range from conducting specific laboratory experiments to develop factors or coefficients for mathematical models, to determining the quality of leachate from dredged or solid waste materials, to the conduction of large scale field experiments to measure changes in environmental features as a result of system perturbations.

The most sophisticated approach for impact prediction involves the selection and use of quantitative models for predicting pollutant transport and fate and environmental cycling. In addition, models have been developed for addressing environmental features and the functioning of ecosystems, and system responses to man-induced perturbations. With regard to air quality dispersion, there are numerous models which have been developed to address point, line, and area sources of air pollution and the results of dispersion from these sources (Turner, 1994; and U.S. Environmental Protection Agency, 1993). Hydrological models can be used to address rainfall-runoff relationships, surface and subsurface flows, and estuarine and coastal hydrodynamics (Anderson and Burt, 1985; and James, 1993). Surface and ground water quality models are also plentiful, with major research developments within the last decade occurring in the realm of solute transport in subsurface systems. Surface water quality and quantity models range from one dimensional steady-state models to three dimensional dynamic models which can be utilized for rivers, lakes, and estuarine systems (Henderson-Sellers, 1991; James, 1993; and U.S. Army

Corps of Engineers, 1987). Ground water flow models have been recently modified to include subsurface processes such as adsorption and biological decomposition (Water Science and Technology Board, 1990).

Noise impact prediction models have been developed for point, line, and area sources of noise generation (Magrab, 1975; and World Health Organization, 1986). These models range in complexity from simple calculations involving the use of nomographs to sophisticated computer modeling for airport operations.

Expert systems refer to computer programs that encode the knowledge and reasoning used by specialists to solve difficult problems in narrowly defined domains. They rely more on heuristic rules-of-thumb and pattern matching to achieve their results, rather than numerical models and algorithms. A key advantage is the ability to use the collective knowledge of a number of experts rather than one single expert. Several expert systems have been developed for the physical-chemical environment.

Biological impact prediction models are often based on the use of habitat approaches. These index-based models include the Habitat Evaluation Procedures (HEP) developed by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service, 1980), and the Habitat Evaluation System (HES) and the Wetland Evaluation Technique (WET) developed by the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers, 1980; and Adamus, et al., 1987). Other models include species population models, species diversity indices, and biophysical models used for estimating chemical cycling and interchanges in terrestrial or aquatic ecosystems. Energy system diagrams which account for energy flows within and between system components have also been used in some impact studies.

Risk assessment (RA) traditionally encompasses components of hazard (risk) identification, dose-response assessment, exposure assessment, and risk characterization. In recent years, attention has been directed toward the incorporation of RA principles in the EIA process, with such principles useful for examining both human health and ecological risks.

Predictive modeling is also possible for ascertaining the potential presence of historical or archaeological resources in geographical study areas (King, 1978). Such modeling is based upon evaluating a series of factors to indicate the likelihood of historical or archaeological resources being found; the factors are related to existing information, the likelihood for early occupations in the area, and other biophysical and sociological factors.

Visual impact models typically involve the evaluation of a series of factors, in some cases quantitatively and in other cases descriptively or by category, with the assemblage of the information into an overall visual quality or resources index for the study area.

Impact prediction related to the socioeconomic environment is often associated with the use of human population and econometric models (Canter, Atkinson, and Leistritz, 1985). Population forecasting can range in sophistication from simple projections of historical trends to complicated cohort analysis models. Econometric models relate the population and economic characteristics of study areas so that interrelationships can be depicted between population changes and changes in economic features within given study areas. Other impact predictions for the socioeconomic environment, such as impacts on educational or transportation systems can be addressed via multiplier factors applied to population changes. Health impact predictions may utilize descriptive (or conceptual) models, statistical models, matrices, or cause/effect diagrams (Turnbull, 1992).

Table 6.4 delineates substantive area examples of specific methods (techniques) that could be used for impact prediction within the EIA process; and many of them can be directly applied in CEA (Canter, 1997a). It should be understood that the listed techniques are not all mathematical models, nor do they represent a comprehensive delineation of all potential methods. Within each of the substantive areas typically addressed in an impact study, several techniques are available for impact prediction.

EXAMPLES OF PREDICTION METHODS USED IN CEA CASE STUDIES

Examples of methods used for cumulative effects identification and prediction in 25 case studies are in Table 6.5. It should be recognized that these examples are not intended to be comprehensive, rather, they are indicative of the types of methods being used in CEA practice. The listed methods range from scoping to the use of quantitative modeling. To serve as a more specific illustration, Table 6.6 lists prediction methods for cumulative effects used by the U.S. Army Corps of Engineers in 5 EISs, and also by the U.S. Forest Service in 5 EISs (Cooper, 1995). Most of the studies used several methods in the quantification of cumulative effects. Further, several prediction methods have been developed for certain types of watershed cumulative effects. Summary information on eight methods developed in California and the Pacific Northwest region of the United States is included in Table 6.7 (after Reid, 1993). Additional details on the characteristics of these methods are summarized in Table 6.8, and also found in Reid (1993).

Finally, examples of still more types of cumulative effects prediction methods include:

(1) Energy balances and mass balances have been suggested as useful prediction tools in CEA (Roots, 1986).

(2) Stress-response modeling refers to a general framework which can be used to predict the response of environmental systems to perturbations (Spaling, 1994).

(3) Suitability analyses which examine the characteristics of a region and identify areas that are appropriate for or sensitive to different types of development are one type of method which can be used in CEA (Contant and Wiggins, 1993). Overlay mapping and the use of GIS can facilitate suitability analyses. Such analyses do not involve predictions of cumulative effects; rather, these effects are implicitly considered in the context of the ability of natural systems to withstand developmental pressures.

(4) GIS can be used in mapping historical and current baseline conditions for land uses and biophysical features within the study boundaries of a CEA. This tool can also be used to develop qualitative/quantitative relationships between environmental processes and resources. For example, a CEA method involving aerial photointerpretation, multivariate statistical analysis, and GIS techniques was developed to relate wetland abundance with stream water quality in the Minneapolis-St. Paul metropolitan area in Minnesota in the USA (Johnston, et al., 1988).

(5) Carrying capacity studies are another type of CEA method. Such studies recognize that biophysical and socio-economic systems have inherent limits (or limiting factors), thus these

Table 6.4: **Examples of Impact Prediction Techniques Organized by Substantive Areas (Canter, 1997a)**

- **Air**
  - (1) emission inventory
  - (2) urban area statistical models
  - (3) receptor monitoring
  - (4) box models
  - (5) single to multiple source dispersion models
  - (6) monitoring from analogs
  - (7) air quality indices
- **Surface Water**
  - (1) point and nonpoint waste loads
  - (2) QUAL-IIE and many other quantitative models
  - (3) segment box models
  - (4) waste load allocations
  - (5) water quality indices
  - (6) statistical models for selected parameters
  - (7) water usage studies
- **Ground Water**
  - (1) pollution source surveys
  - (2) soil and/or ground water vulnerability indices
  - (3) pollution source indices
  - (4) leachate testing
  - (5) flow and solute transport models
  - (6) relative subsurface transport models
- **Noise**
  - (1) individual source propagation models plus additive model
  - (2) statistical model of noise based on population
  - (3) noise impact indices
- **Biological**
  - (1) chronic toxicity testing
  - (2) habitat-based methods
  - (3) species population models
  - (4) diversity indices
  - (5) indicators
  - (6) biological assessments
  - (7) ecologically-based risk assessment
- **Historical/archaeological**
  - (1) inventory of resources and effects
  - (2) predictive modeling
  - (3) prioritization of resources
- **Visual**
  - (1) baseline inventory
  - (2) questionnaire checklist
  - (3) photographic or photomontage approach
  - (4) computer simulation modeling
  - (5) visual impact index methods
- **Socioeconomic**
  - (1) demographic models
  - (2) econometric models
  - (3) descriptive checklists
  - (4) multiplier factors based on population or economic changes
  - (5) quality-of-life (QOL) indices
  - (6) health-based risk assessment

Table 6.5: Examples of Use of Identification and Prediction Methods in CEA

Case Study	Reference
Use of GIS for terrestrial habitat analysis in conjunction with examining the cumulative effects on wildlife of oil and gas developments in Alberta, Canada	Eccles, et al. (1994)
Use of information on wetland functions and processes to qualitatively estimate the cumulative effects of wetland alteration on hydrology and/or water quality, or the cumulative effects of other projects on wetland resources	Brinson (1988); Hemond and Benoit (1988); and Winter (1988)
Use of "scoping" workshop to identify key cumulative effects on aquatic ecosystems for development projects in the Hudson and James Bay areas of northern Canada	Bunch and Reeves (1992)
Use of stepped matrices for cumulative effects identification for open cut mining of black coal in Australia	Court, Wright, and Guthrie (1994)
Use of cause-effects networks for coastal zone regional development in Australia	Court, Wright, and Guthrie (1994)
Use of adaptive environmental assessment and management (AEAM) for cumulative effects on wetlands in the Johnson River Catchment in Queensland, Australia	Court, Wright and Guthrie (1994)
Use of GIS for mapping cumulative acid deposition from 49 space shuttle launches in Florida, and for empirically testing a rocket exhaust effluent diffusion model	Duncan and Schmalzer (1994)
Use of impact rating and resource importance weighting, via the "Cluster Impact Assessment" Procedure (CIAP) of the U.S. Federal Energy Regulatory Commission to examine cumulative impacts from multiple hydropower projects in a river basin	Emery (1986)
Use of scoping workshop for issues identification in a CEA for multiple development projects in the Slave Geological Province in Canada	ESSA Technologies, Ltd. (1994)
Use of GIS for mapping special aquatic sites and dredge and fill activities in a CEA study of Commencement Bay near Tacoma, Washington, in the USA	David Evans and Associates, Inc. (1991)
Use of GIS for examining cumulative effects to the spatial configuration and functions of forested wetlands	Johnston (1994)
Use of CIAP (rating-weighting matrix) in a CEA of 15 small hydropower projects in the Salmon River Basin in Idaho in the USA	Irving and Bain (1989 and 1993)
Use of a cumulative impact matrix to summarize additive, synergistic, and indirect cumulative effects on wetlands over time and space	Risser (1988)

Table 6.5 (continued):

Use of a coastal habitat evaluation method based on habitat area and functional attributes to examine cumulative effects in coastal areas in the USA	Ray (1994)
Use of hydrologic indices based on harmonic analysis and time-scale analysis of stream flows to examine cumulative effects on wetlands	Nestler and Long (1994)
Use of a streamflow and dissolved solids load routing model to examine the cumulative effects of anticipated coal mining on the salinity of the Price, San Raphael, and Green Rivers in Utah in the USA	Lindskov (1986)
Use of indicators of landscape structure and function in CEAs for bottomland hardwood forest wetlands in the southeastern USA	Lee and Gosselink (1988)
Scientifically-based professional judgment approach for CEAs of waterbird habitat in wetlands in the USA	Weller (1988)
Use of CIAP (rating-weighting matrix) for predicting cumulative effects of hydropower projects on wintering bald eagles in two river basins in western Washington in the USA	Witmer and O'Neil (1988)
Use of CIAP (rating-weighting matrix) for predicting cumulative effects of 15 hydropower projects on elk and mule deer in the Salmon River basin in Idaho in the USA	O'Neil and Witmer (1988)
Use of GIS and geobotanical mapping to document historical impacts and predict the cumulative effects of oil developments in northern Alaska (Prudhoe Bay) in the USA	Walker, et al. (1987)
Use of professional knowledge and experience on typical impacts of hydroelectric projects on fish and wildlife to predict cumulative effects in the Columbia River basin in Washington in the USA	Stull, et al. (1987)
Use of qualitative fish habitat model for predicting the cumulative effects of development projects on fish resources in the Kenai River in Alaska in the USA	Vestal, et al. (1995)
Use of a qualitative landscape conservation approach based on a landscape-level analysis and identified environmental goals, along with professional judgment, to examine the cumulative effects of development scenarios in the Tensas River Basin in Mississippi in the USA	Vestal, et al. (1995)
Use of GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) and EXAMS (Exposure Analysis Modeling System) to quantify the potential cumulative effects of insecticide application for boll weevil control in the USA	Myslicki (1993)

Table 6.6: Examples of Cumulative Effects Prediction Methods Used by Two Federal Agencies in the United States (Cooper, 1995)

Agency	Type of Project	Prediction Methods
U.S. Army Corps of Engineers	River channel and floodplain development	• QUAL-TX (water quality model) • Habitat Evaluation Procedure (HEP) (wildlife effects) • GIS • HEC-1 (surface water runoff)
	Hurricane/flood protection	• HEP (fish and wildlife effects) • Habitat Evaluation System (HES) (fish and wildlife effects)
	River navigation	• CONGEST (navigation traffic flow)
	Flood control	• Watershed Hydrologic Simulation Model (watershed runoff) • GIS • Overlay mapping
	Dam/reservoir	• Specific water temperature and water turbidity models • CE-THERM (reservoir processes model) • QUAL II (water quality model) • GIS • HEP (wildlife) • HEC-5 (flood control and conservation)
U.S. Forest Service	Land development	• Habitat model (for red squirrel) • Population dynamics model (for red squirrel)
	Timber sale	• RO3WILD model (habitat capability indices for various wildlife species)
	Timber sale	• Simple Approach Smoke Estimation Model (air quality effects from particulates) • BOISED Model (sediment yields) • GIS • Elk Habitat Effectiveness Model
	Ski area development	• Box model (air quality) • Complex I (atmospheric transport and dispersion model) • TRANSPLAN model (transportation effects)
	Timber sales	• Forest Equivalent Roaded Area Model (sedimentation, peak flows, and changes in channel stability)

Table 6.7: Examples of Prediction Methods for Cumulative Watershed Effects (Reid, 1993)

	Equivalent Clearcut Area Analysis	Klock Watershed Cumulative Effects	Equivalent Roaded Area	R-1/R-4 Sediment-Fish Model	CDF Questionnaire	WRENSS	Limiting Factor Analysis	Rational Approach (Grant)
Model type	empirical association	weighted indices	use intensity index	empirical process-base	checklist	physical process	sum impacts; process	physical process
Result	water yield, peak flow	index	index	rates and populations	qualitative	various process rates	smolt production	critical flow
Impact mechanism	vegetation change alters water yield and destabilizes channels	sheetwash, slides introduce sediment and destabilize channels	impacts increase with increasing intensity of use	eroded sediment in channels impact fish	all may be considered	depends on module	habitat change alters fish survival and population	increased bedload transport alters channel
Land use	logging, roads	logging, roads	logging, roads	logging, roads	logging, roads	logging, roads	not specified	not specified
Impacts	not specified	not specified	not specified	fish	water quality, fish, recreation, others	not specified	coho smolt production	not specified
Calibration required	water yield increase by habitat, practice, elevation, region	slide survey, runoff relative to roads	impact intensity vs. index; pct. change for uses relative to roads	relations between sediment, habitat, and fish	user must thoroughly understand processes and impacts of region	depends on module	relations between fish density and habitat parameters	no
Data required for use	use history, area of each use unit	use history, area of each use	use history, area of use units, site factors	use history, use unit areas, habitat and fish surveys	may use any information source	much data required for most procedures	population and habitat inventories	measured channel characteristics

Notes: Klock refers to name of developer of Klock Watershed Cumulative Effects method; R-1/R-4 refers to Regions 1 and 4 of the U.S. Forest Service; CDF is the California Department of Forestry and Fire Protection; WRENSS stands for Water Resources Evaluation of Non-point Silvicultural Sources; Grant refers to the developer of the Rational Approach.

Table 6.8: **Potential Uses and Characteristics of Prediction Methods for Cumulative Watershed Effects (Reid, 1993)**

	BCA	KWCEA	ERA	S/F	CDF	WRENSS	LFA	RA
Uses considered								
Timber management	x	x	x	x	x	x	.	.
Roads	x	x	x	x	x	x	.	.
Mining	c	.	c	c	x	(x)	.	.
Agriculture	c	.	c	c	x	(x)	.	.
Recreation	c	.	c	c	x	(x)	.	.
Urbanization	c	.	c	c	x	(x)	.	.
Impoundments	.	.	.	.	x	.	.	.
Mechanisms:								
Runoff change	x	.	x	.	x	x	x	.
Peak flow change	x	.	x	.	x	x	x	x
Sediment change	.	x	x	x	x	x	x	.
Organic debris change	.	.	.	.	x	.	x	.
Nutrient change	.	.	.	.	x	x	.	.
Input of toxics	.	.	.	.	x	x	.	.
Temperature change	.	.	.	.	x	x	x	.
Impact:								
Channel stability	x	x	x	.	x	x	.	x
Fish	.	.	.	x	x	.	x	.
Recreation	.	.	.	.	x	.	.	.
Water quality	.	.	x	x	x	x	.	.
Sedimentation	.	.	x	x	x	x	.	.
Form of result:								
Index	.	x	x	.	.	.	.	.
Rate or value	x	.	.	x	.	x	x	x
Qualitative	.	.	.	.	x	x	.	.
Scientific basis:								
Theoretical	.	.	.	x	n	(x)	x	x
Empirical	x	n	x	x	n	(x)	x	n
Validation	.	n	.	.	.	(x)	*	n
Source:								
Research	.	n	.	x	.	x	x	x
Management	x	n	x	x	x	.	x	.

x Model applies
. Model does not apply
c Model could apply if calibrated
n Not specified or unknown
(x) Varies with procedure
* In progress

BCA Equivalent Clearcut Area
KWCEA Klock Watershed Cumulative Effects Analysis
ERA Equivalent Roaded Area
S/F R-1/R-4 Sediment Fish Model
CDF California Department of Forestry Questionnaire
WRENSS Water Resources Evaluation of Non-point Silvicultural Sources
LFA Limiting Factor Analysis
RA Rational Approach (Grant)

constraints on development are identified. Further, mechanisms for monitoring the incremental use of any unused system capacity can be identified (Contant and Wiggins, 1993).

(6) **EXAMS** (Exposure Analysis Modeling System) was developed by the U.S. Environmental Protection Agency for modeling the transport and fate of a wide variety of chemicals in aquatic environments; the latest version is called EXAMS II (Myslicki, 1993).

(7) The "societal growth induction" capability of the proposed project may also need to be addressed in CEA (Contant and Wiggins, 1993). Growth induction refers to the fact that the introduction of certain activities can accelerate or decelerate the rate of development of new activities. Thus certain activities may have a precedent-setting effect in stimulating even greater development than previously anticipated.

(8) **IMPLAN** is an economic input-output model developed by the U.S. Forest Service for estimating the effects of their various actions on employment, income, population, and other parameters at the county level and any higher aggregate affected area (Myslicki, 1993). It can also be used to examine cumulative socio-economic effects resulting from many types of federal and private development actions.

(9) **Bounding analyses** refer to simplified quantitative analyses that incorporate conservative assumptions and analytical techniques to ensure that the potential impacts of proposed actions are not underestimated (Saylor and McCold, 1994). The "bounds" could be selected so as to represent "best case" and "worst case" conditions. Such quantitative analyses can be useful for both project-level and strategic impact studies, and for CEAs within these studies. Saylor and McCold (1994) suggested that bounding analysis can be useful: (1) when an impact is expected to be insignificant; (2) when considering the generic impacts of a category of action; (3) in the preparation of programmatic EISs (also called SEAs); and (4) for accident analyses and assessments for low-probability, high-consequence events.

<u>Cumulative Effects on Air Quality -- Examples of Prediction Methods and a Protocol</u>

A "state-of-practice" review of 27 impact study documents (19 final EISs and 8 final EAs) prepared by one large U.S. federal agency (the U.S. Air Force) was recently completed (Rumrill and Canter, 1998). The documents, prepared from 1989 to 1996, represented more than 12% of such EISs/EAs prepared by the agency in the time period. While this small percentage cannot be considered as statistically representative, the study documents can be viewed as indicative of CEA practice in this agency. The documents were systematically examined regarding the approaches and quantification methods used to address cumulative effects on one environmental resource -- ambient air quality. It was found that seven documents included some type of quantitative emission estimation, typically linked to the project-specific air quality impact quantification, and an additional nine cases included a qualitative discussion. Thirteen documents included cumulative effects considerations on both local and regional spatial scales. They all accessed regional monitoring data to determine the regional ambient pollutant concentration

levels without the contemplated action. All 13 also contained project-specific quantitative emissions estimations, predictions, and analysis of the air quality impacts anticipated from the proposed action and its alternatives. Ten of the EISs and one EA included some type of project-specific air quality modeling results. Finally, 11 cases provided some type of guideline for the determination of the significance of the air quality impacts.

The accomplishments and limitations discovered through the analysis of the 27 documents were utilized as the basis for the development of an 8-step protocol for conducting a "cumulative air quality effects assessment" (CAQEA). Table 6.9 summarizes the eight steps. The steps can be accomplished either as an integral part of the EIA process applied to a specific project; or via a separate study for a general area and timeframe and incorporated by reference into individual project assessments. It is noteworthy that the requirements for an adequate CEA of air quality closely parallel the requirements for adequate study of project-specific air quality effects. For example, six steps for a project-specific air quality effects study are shown in Table 6.10 (Canter, 1996), and their linkages to the 8-step CEA- focused method are displayed. For example, in Steps 2, 3 and 5 of the CAQEA method, activities are determined, within a set of time and space boundaries, that are to be analyzed for air quality effects. Also, the type and quantity of emitted pollutants should be estimated. These steps are similar to Step 1 in Canter's model where the specific activities or phases of the proposed action likely to affect air quality are identified. Once identified, pollutant type and quantity estimates are developed for the proposed action. Step 6 of CAQEA and Step 4 of Canter's model are both focused on technical predictions, with possible differences only in the predictive methods or air quality models employed and the level of detail of the analysis. Finally, Steps 7 and 8 of CAQEA are specifically intended to be incorporated within the requirements Canter presents in Steps 5 and 6, respectively.

Indicators and Indices

Indicators can be used in CEA studies; for example, eight indicators of bottomland hardwood ecosystems proposed for use in CEAs of related wetlands are shown in Table 6.11 (Lee and Gosselink, 1988). Alterations of these indicators via development projects could be used to qualitatively predict cumulative effects on wetlands.

Selection of ecological indicators for a CEA study should be based on concepts of ecosystem carrying capacity, assimilative capacity and sustainability; and community values about what makes individual ecosystems healthy and how much degradation is acceptable (Drouin and LeBlanc, 1994). Further, Stevenson (1994) noted the following criteria for consideration in selecting cumulative effects indicators:

(1) availability of secondary data sources;

(2) provision of information on key VECs;

(3) compatibility with and complementarity to indicators used in provincial/regional/national monitoring programs;

(4) usefulness in measuring cumulative effects which are substantial, irreversible, transgenerational, or catalytic;

(5) sensitivity to the magnitude, direction and duration of stress; and

Table 6.9: Steps for Cumulative Air Quality Effects Assessment (CAQEA)

Step	No. of Documents Observed[a]	Comments
1. Select definition of CE to be applied to the analysis.	18	CEQ definition is recommended.
2. Determine spatial and temporal boundaries.	27	Consider physical airshed and political regions (spatial) and forecasting capability limitations (temporal).
3. Determine past, present, and reasonably foreseeable future actions to be included in the analysis.	18	18 documents addressed specific projects identified for inclusion in CEA.
4. Determine background ambient air pollutant concentrations and obtain applicable standards.	21	Regional air quality monitoring station data is recommended.
5. Develop quantitative and qualitative emission data estimates for the actions determined in step 3.	16	Not all 16 documents included both quantitative and qualitative analysis.
6. Determine quantitative and qualitative change to background air quality (determined in step 4) resulting from evaluated actions.	16	Not all 16 documents included both quantitative and qualitative analysis. Emissions inventories and quantitative air quality modeling can be useful.
7. Evaluate the CE significance in context with the air quality impacts of the action originally generating the NEPA requirement and incorporate that significance into the assessment.	0	Necessary to properly determine impact significance.
8. Include mitigation opportunities for CEs when discussing specific action impact mitigation.	0	Additional mitigation opportunities/options are available when other activities are considered.

[a]Out of 27 documents in the study group
CE = cumulative effects

Table 6.10: Comparison between Canter's 6-Step Project-Specific Model and the 8-Steps for CAQEA

1. Select definition of CE to be applied to the analysis.		
2. Determine spatial and temporal boundaries.	Step 1:	Identification of Air Quality Impacts of Proposed Project
3. Determine past, present, and reasonably foreseeable future actions to be included in the analysis.	Step 2:	Description of Existing Air Environment Conditions
4. Determine background ambient air pollutant concentrations and obtain applicable standards.	Step 3:	Procurement of Relevant Air Quality Standards and/or Guidelines
5. Develop quantitative and qualitative emission data estimates for the actions determined in step 3.	Step 4:	Impact Prediction (technical)
6. Determine quantitative and qualitative change to background air quality (determined in step 4) resulting from evaluated actions.	Step 5:	Assessment of Impact Significance
7. Evaluate the CE significance in context with the air quality impacts of the action originally generating the NEPA requirement and incorporate that significance into the assessment.	Step 6:	Identification and Incorporation of Mitigation Measures
8. Include mitigation opportunities for CEs when discussing specific action impact mitigation.		

Table 6.11: Indicators of Bottomland Hardwood (BLH) Landscape Structure and Function (after Lee and Gosselink, 1988)

Indicator	Definition
1. Fraction of BLH remaining	BLH remaining as % of historical or potential
2. BLH patch size distribution	Size-frequency distribution of BLH patches
3. Contiguity: a. BLH to stream b. BLH to upland forest	 Length of BLH-stream interface/2 x stream length Length of BLH-upland forest interface/total BLH-upland interface
4. Water quality	Historical change in flow-adjusted concentration of phosphorus
5. Nutrient loading	Total nutrient input/water flux
6. Stage-discharge relations	Historical changes in stage-discharge rating curves
7. Water detention	Volume of water stored on floodplain/discharge
8. Balanced indigenous populations	Old growth stands; endangered/threatened species; presence/absence of indicator species; change in bird species richness

(6) usefulness for predicting thresholds, measuring assimilative capacities, and anticipating and monitoring change.

Environmental indices can be useful for describing baseline environmental conditions and considering potential cumulative effects. For example, indices of biotic integrity (IsBI) are being utilized in the State of Maryland in the United States for establishing the aquatic environment conditions for a cumulative effects study of electric power generating and transmission systems. Such indices, which to date have been developed for fish, represent the "health or integrity" of aquatic biological communities (Southerland, et al., 1997).

The U.S. Environmental Protection Agency developed a synoptic approach for CEAs of wetlands (Leibowitz, et al., 1992). This rapid assessment approach uses indicators and developed indices to facilitate qualitative comparisons of cumulative effects between different areas such as watersheds, landscape units or ecoregions (Vestal, et al., 1995). The key components of this approach are "synoptic indices." Such indices are composed of variables used to compare landscape subunits, which will generally indicate function, values, functional loss, or replacement potential. Synoptic indices are developed based on a conceptual, ecological model of the forces and functions driving the wetlands, identifying the stressors in the particular area, and choosing which landscape indicators to use to comprise the indices. The indices are mapped and can be used to rank units of the landscape. These results are useful in examining potential cumulative effects from developments in specific geographical areas.

Qualitative Habitat Methods

Three examples of qualitative habitat methods for use in cumulative effects predictions can be noted. For example, a fish habitat-based approach has been used by the State of Alaska in the USA to examine the cumulative effects of development and human uses on the physical and biological integrity of the Kenai River's habitat for resident and anadromous fish. The CEA methodology included the following steps (Vestal, et al., 1995):

(1) Identify the target resource (fish habitat) and develop a fish habitat classification scheme.

(2) Develop a baseline description of the conditions occurring along the Kenai River correlated to individual land ownership patterns.

(3) Select and apply a qualitative fish habitat value model procedure (the procedure included indicator species and habitat suitability rating curves).

(4) Complete a development trends analysis by examining historical and current projects and future development plans and projects.

(5) Model future changes in habitat characteristics based on examining the influence of development scenarios on the qualitative fish habitat model.

This use of a fish habitat-based approach is similar to the index-related models included in the Habitat Evaluation System of the U.S. Army Corps of Engineers for aquatic habitats. It is also conceptually similar to habitat suitability index models for fish species developed as part of the Habitat Evaluation Procedure of the U.S. Fish and Wildlife Service.

The National Marine Fisheries Service (NMFS) in the United States has developed and tested a CEA protocol for coastal and marine ecosystems potentially subjected to cumulative effects from wetland and waterway development projects. The steps in the protocol are summarized in Table 6.12 (Vestal, et al., 1995). The NMFS has examined two approaches for implementing the protocol -- a key indicator species (IS) approach and a habitat-based landscape (HL) approach. The IS approach stresses the cumulative effects of specific development-related impacts on the ecological requirements of a population of an indicator species; while the HL approach emphasizes the cumulative effects of the incremental degradation and loss over time of important habitat functions throughout an ecologically defined landscape setting (Vestal, et al., 1995).

The IS approach involves defining the habitats of concern and selecting one or more indicator species. For each selected species, key ecological factors which relate to its survival are identified. An interaction matrix is then developed to identify effects from development projects on the key ecological factors and, in turn, the indicator species. The HL approach traces the progression of coastal development and habitat loss in function, size, and value in a given landscape setting over time. Proposals for new developments are then considered in the context of this data to assess cumulative effects. Both approaches rely upon the considerable exercise of professional judgment. However, in general, the HL approach is useful where a variety of habitat types or functions appear to have been affected by previous development, so that an analysis of impacts to indicator species may not adequately represent the cumulative effects of coastal development. Finally, the IS and the HL approaches differ in orientation, with the former taking a "bottom up" perspective by projecting broad scale effects based on the site-specific ecological requirements of representative species. The HL approach takes a "top down" perspective, using historical records to document habitat loss, and inferring impacts to living marine resources according to the type and quantity of habitat functions lost over time (Vestal, et al., 1995).

Cluster Impact Assessment Procedure and the Integrated Tabular Method -- Applications for Small Hydroelectric Projects

The Cluster Impact Assessment Procedure (CIAP) was developed by the U.S. Federal Energy Regulatory Commission for use in CEAs of small hydroelectric power projects (typically 10 MW or less) in the Pacific Northwest region of the United States. The central feature of CIAP is the calculation of a total cumulative impact score for selected fish or wildlife species based on individual project impacts plus (or minus) related interaction impacts (Irving and Bain, 1989). The method involves the assignment of numerical impact ratings for target species based on pre-defined criteria for life cycle components (or processes) of the species. The relative importance of the components (or processes) is then considered along with potential interaction effects between the components (or processes). The total impact score is the product of pertinent ratings and importance weights considering the project by itself, its interaction effects, and related projects in the study area. The CIAP has been applied in a CEA of 15 small hydroelectric projects in the Salmon River Basin located in Idaho in the USA (Irving and Bain, 1989). Such an approach was supported by Eckberg (1986) when he presented litigative-

Table 6.12: CEA Protocol for Coastal and Marine Ecosystems (after Vestal, et al., 1995)

Step 1: Determine Whether to Review in Depth for Cumulative Effects

For each proposed coastal development project, determine whether detailed cumulative effects review is appropriate. In general, projects may be considered appropriate for review under the Protocol if the project site, surrounding area, and/or types of resources at risk have been subject to substantial yet incremental environmental impacts, resulting in a decrease in the amount or quality of environmental functions and values.

Step 2: Collect and Synthesize Information

(a) For each project that warrants more detailed cumulative effects review, select and define a coastal geographic area that constitutes a landscape unit and has definable ecological boundaries to be studied for cumulative effects. Conduct a literature search to identify major components of the ecosystem, its former and existing condition (if different), and its specific functions and values which could be affected cumulatively from coastal development. Seek out researchers who have conducted or are conducting investigations that could prove helpful in understanding specific resource functions, processes, and impacts.

(b) Document resource use of and reliance upon the identified landscape unit. This can be based on collecting, reviewing, and citing life history information for ecologically important species; citing coastal ecology literature for habitat functions and values; and using life history and habitat information to describe the use of the selected geographic area by species, including food web relationships, shelter from predators, etc.

(c) Identify indicators of ecosystem condition in the project area such as water quality, sediment quality, or the presence of sensitive resources (e.g., eelgrass beds).

(d) Document possible anthropogenic sources of stress to the selected area, e.g., pollutant inputs, changes to freshwater flow and salinity, habitat alteration or destruction, and fishing pressure. Obtain historical information on habitat loss or degradation due to permitted and unregulated activities.

Step 3: Identify Goals and Objectives for Project Area

Identify the desired future condition for the resource area within its geographic context. This information may be obtained from existing planning documents of several governmental agencies and entities.

Table 6.12 (continued):

Step 4: Evaluate Individual Projects Using the Protocol

(a) Determine what functions or processes would be affected by the project in the selected area, using site visits, review of project files, related impact study documents, literature about the area, and/or state, local, or regional plans.

(b) Quantify the amount of habitat loss or degradation from the project, including types of habitat functions/values lost and the acreage lost or degraded.

(c) Assemble historical information on habitat quantity and quality in the watershed and landscape area surrounding the project site to determine previous conditions and cumulative losses to date. Use sources such as existing habitat maps, old aerial photos, U.S. Army Corps of Engineers permit files, historical records, and interviews with landowners and local officials.

(d) Project any potential future habitat impacts to the project area due to other foreseeable activities. Include impacts from similar types of projects or different activities affecting the same landscape area, and use any available trends information from town planners, chambers of commerce, regional planning documents, etc.

(e) Project or calculate the additive total of habitat loss or degradation from similar projects in the geographical area.

(f) Combine data generated in (a) through (e) above to gauge the cumulative effect of the project together with past and anticipated future projects in the area, and draw ecological connections between the types of impacts identified and the species of concern to NMFS.

based arguments for using a river-basin approach in examining the cumulative effects of small hydropower projects.

The CIAP was developed by the U.S. Federal Energy Regulatory Commission as a method for assessing the cumulative effects of multiple hydroelectric projects in a river basin. The steps in CIAP include (Hochberg, Friday, and Stroup, 1993):

Step 1: A workshop is conducted to define goals, determine the number and location of projects, determine target resources and their associated components (e.g., bald eagle food supply and roost habitat), and assign evaluative impact ratings. Ratings represent impact magnitudes on a standardized scale. A combination of quantitative values and qualitative descriptions is used to formulate the criteria. The total cumulative impact of multiple projects is then represented by the relationship:

Cumulative impacts = sum of project impacts + interaction impacts.

Step 2: Each targeted resource component is rated, and the total cumulative impact ratings for all possible combinations are calculated.

Step 3: Projects that exceed an allowable level of impact for one or more resource components are flagged based on biological thresholds, liming factors, or management objectives. Project combinations with one or more flagged projects are screened out.

Step 4: Preferred project combinations are identified, and the cumulative impacts of preferred project combinations are described and summarized.

Stull, et al. (1987a) described a CEA method for quantifying the cumulative effects to fish (chinook salmon) and wildlife (elk) of hydropower projects in the Columbia River Basin in the United States. The method, called the Integrated Tabular Method (ITM), addresses both habitat and population effects. The ITM can be considered as an expansion of the CIAP in that interactions between single project effects can be quantified (Hochberg, Friday, and Stroup, 1993). The flow diagram of ITM is displayed in Figure 6.1 (Stull, et al., 1987a). The first step on geographic boundaries and study scope establishes the context of the CEA. Geographic boundaries can be based on features of the natural environment, institutional boundaries such as management areas, the "impact footprint" of a typical project, and project locations. Study scope can involve establishing the number and locations of past, present, and future projects; and selecting one to several target fish and wildlife species or natural resources. Decisions on geographic boundaries and study scope should also be tempered by the consideration of information requirements and sources of such information (Step 2). The end result of Steps 1 and 2 should be a map showing the potentially affected habitats or resources or populations of the target species.

The design of a strategy for accumulating and aggregated cumulative effects on target species or resources (Step 3) should encompass both direct effects on species populations or resources as well as effects resulting from changes in the physical-chemical environment; e.g., changes in river flows and water quality. Another consideration related to Step 3 is associated with the way in which a population of the target species

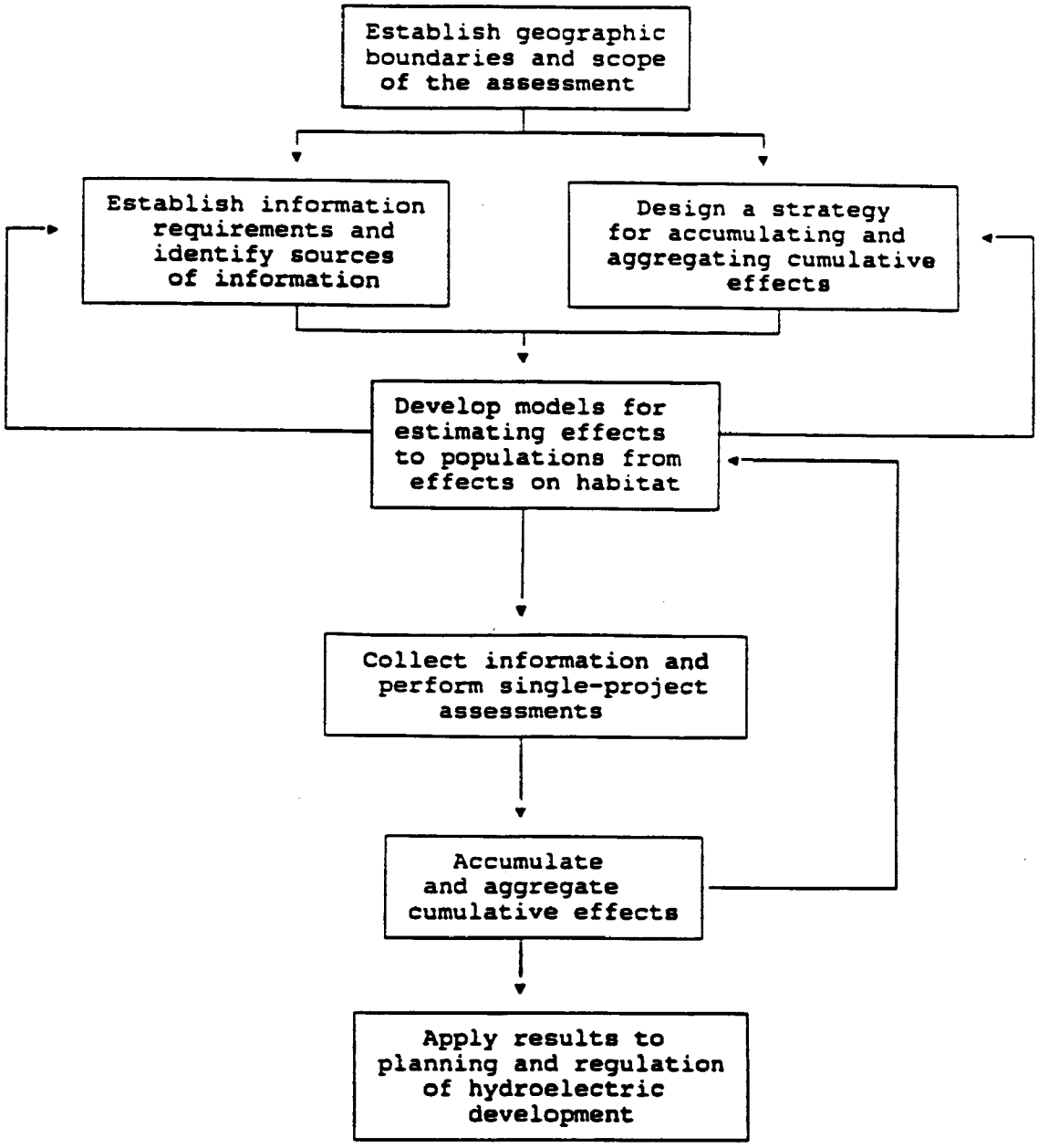


Figure 6.1: Flow Diagram of the ITM (after Stull, et al., 1987a)

responds to multiple direct and related effects. In this regard, the issue is related to whether the effects are additive, synergistic, or antagonistic; and whether the species exhibits resiliency and/or recoverability. Accordingly, either a univariate or multivariate approach may be required.

Step 4 in the ITM involves the development of models to quantify the habitat and population changes resulting from hydroelectric development projects. The models could be developed via use of AEAM workshops and simulation exercises, taking into consideration data availability and professional knowledge and experience.

Once the models are developed, they can be applied to both single project assessments (Step 5) and CEAs of multiple projects (Step 6). The models can range from very simple ones in which the effect is directly related to a single property such as riparian habitat, to complex ones in which the effects are due to non-additive combinations of changes to several influencing factors or properties. The effects of projects on various species or resources should be expressed in units that directly reflect the magnitude of the effect (e.g., number of adult individuals lost, acres of habitat lost) rather than qualitative criteria (Stull, et al., 1987a).

The key element of ITM is Step 4 on model development, and a fundamental component would be response curves for target species (or resources) based on specific effect variables (Hochberg, Friday, and Stroup, 1993). Additional components are interaction coefficients (i.e., the quantity used to calculate the change in a project's impact caused by the influence of another project) which are based on the response curves. Interaction coefficients should be determined for all pairwise permutations of projects in the study area. However, before the interaction coefficients can be calculated, the following steps must be taken (Stull, LaGory, and Vinikour, 1987):

(1) The overlap areas of the project impact zones must be determined; these areas can be determined by the following methods: (1) area size (area of overlap/area of impact); (2) habitat (habitat in overlap/entire habitat; (3) population (population in overlap/entire population); and (4) impact (impact in overlap/entire impact).

(2) The project impact zones must be segmented, if necessary; river reaches or other areas can be subdivided into as many segments as are supported by the quantity of data available from the single project assessments.

(3) Shared project features must be identified; when the effects of several projects are accumulated, the resulting estimate of cumulative effect will be too high unless some adjustment for the shared project features is made (e.g., projects sharing roads and transmission lines). To correctly calculate the interaction coefficient when a shared project feature is in the overlap area, the response of the population to the shared project feature must be added to the calculation.

(4) The nonlinearity of the species responses to the combined effects of different pairs of projects must be determined.

An equation for calculating interaction coefficients, based on overlapping project impact zones as shown in Figure 6.2, is as follows (LaGory, Stull, and Vinikour, 1993):

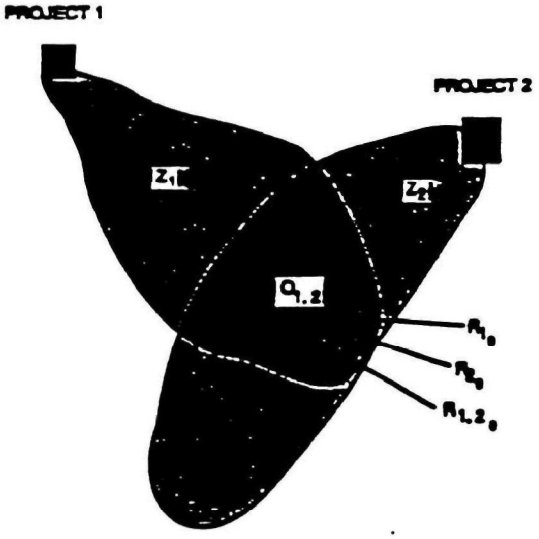


Figure 6.2: **Graphical Depiction of Overlapping Project Impact Zones and Terms Used in Calculating Interaction Coefficients (LaGory, Stull, and Vinikour, 1993)**

$$C_{1,2} = \frac{O_{1,2}}{Z_1} x \frac{R_{1,20} - (R_{10} + R_{20})}{2R_{10}}$$

where $C_{1,2}$ = an interaction coefficient, in this case, the effect of Project 2 on Project 1

$O_{1,2}$ = the area of overlap between the project impact zones of Projects 1 and 2

Z_1 = the area of the impact zone of Project 1

$R_{1,20}$ = the predicted response of the species or resource to both projects in the area of overlap of project impact zones if both projects are built

R_{10} = the predicted response of the species or resource to Project 1 in the area of overlap if only Project 1 is built

R_{20} = the predicted response of the species or resource to Project 2 in the area of overlap if only Project 2 is built

To aggregate cumulative effects, the ITM incorporates both an impact matrix and an interaction matrix for each targeted species. The impact matrix is a single row composed of the single project impacts, while the interaction matrix has many rows and columns (the elements in this matrix are the interaction coefficients representing the ability of the project indicated by the column number to modify the effect of the project indicated by the row number (Stull, LaGory, and Vinikour, 1987).

Additive effects from multiple projects on a single target species are determined simply by adding the effects of each project. With additive accumulation, it is assumed that the effects are incremental and that no interactions occur among the effects that would enhance or diminish the cumulative effect. As shown in Figure 6.3, an additive cumulative effect might be the total acreage of riparian habitat removed during construction of several separate small hydroelectric projects (Stull, et al., 1987a).

To address nonadditive, interactive effects of multiple projects, matrix algebra can be used; this approach has been a feature of both population and ecosystem modeling (Stull, et al., 1987a). To illustrate this concept, Figure 6.4 displays nonadditive, interactive effects and the related matrix calculations. The impact matrix shows the quantified impacts (e.g., acres of habitat loss) on a target species. If the effects were additive the loss for the five projects would be 97 units. However, the project-by-project interaction matrix shows, in each cell, the interaction between the project represented by the row and the project represented by the column. The value in a given cell is zero if no interaction exists between the pairs of projects, positive if the interaction is supra-additive, and negative if the interaction is infra-additive. Ones are assigned to the elements along the main diagonal (the cross comparisons). In the example, the presence of project 1 increases the impact of project 2 by 50% (0.5), and project 2 increases the impact of project 1 by 20% (0.2). To account for interactions among projects, the interaction matrix and the impact matrix are multiplied using matrix

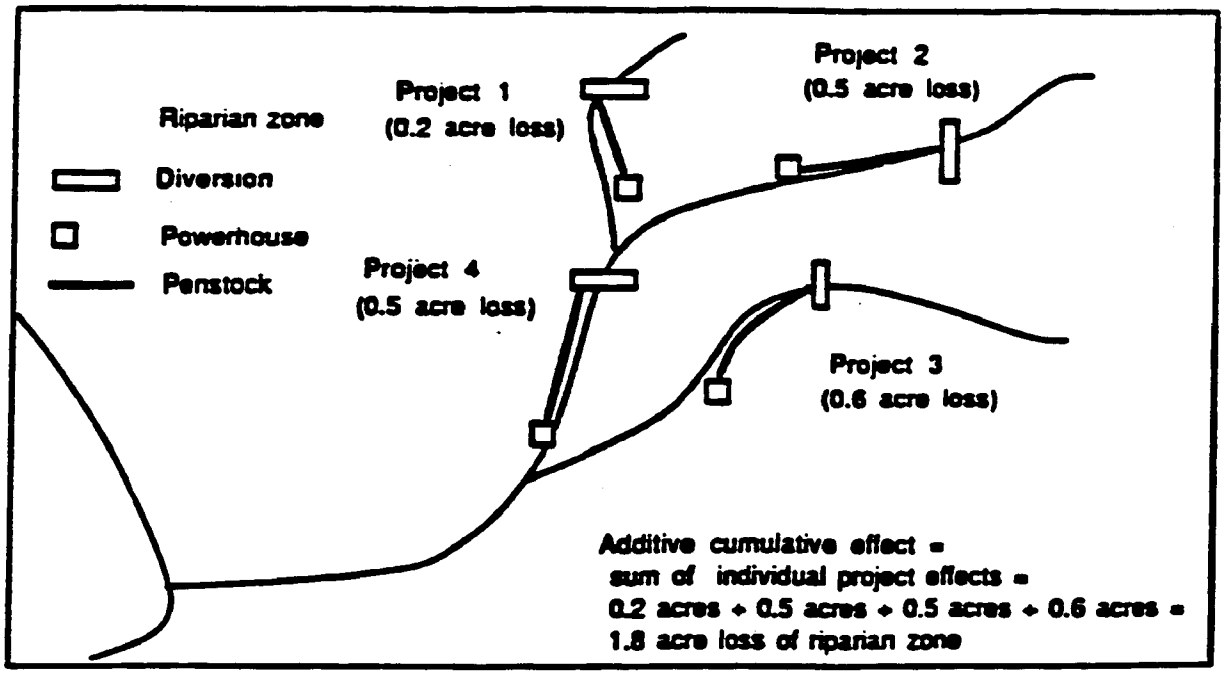
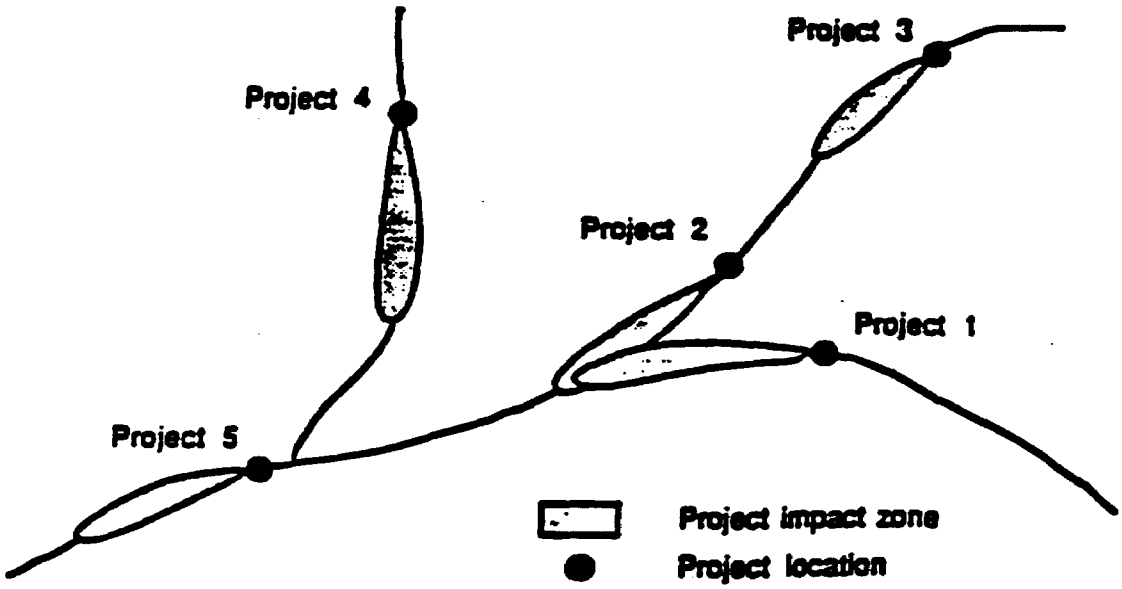


Figure 6.3: Example of an Additive Cumulative Effect from Hydropower Projects in a River Basin (Stull, et al., 1987a)



Impact Matrix

Project

$$\begin{array}{c} \\ \text{Impact} \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ [5 \quad 10 \quad 12 \quad 50 \quad 20] \end{array} \times$$

Interaction Matrix

Effect of project

$$\begin{array}{c} \text{Project affected} \end{array} \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} 1 & 0.2 & 0 & 0 & 0 \\ 0.5 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \end{array}$$

Product Matrix

$$= \left[\begin{pmatrix} 5 \\ \diamond \\ 5 \\ \diamond \\ 0 \\ \diamond \\ 0 \\ \diamond \\ 0 \end{pmatrix} \begin{pmatrix} 1 \\ \diamond \\ 10 \\ \diamond \\ 0 \\ \diamond \\ 0 \\ \diamond \\ 0 \end{pmatrix} \begin{pmatrix} 0 \\ \diamond \\ 0 \\ \diamond \\ 12 \\ \diamond \\ 0 \\ \diamond \\ 0 \end{pmatrix} \begin{pmatrix} 0 \\ \diamond \\ 0 \\ \diamond \\ 0 \\ \diamond \\ 50 \\ \diamond \\ 0 \end{pmatrix} \begin{pmatrix} 0 \\ \diamond \\ 0 \\ \diamond \\ 0 \\ \diamond \\ 0 \\ \diamond \\ 20 \end{pmatrix} \right] = [10 \quad 11 \quad 12 \quad 50 \quad 20]$$

Cumulative effect = sum of elements in product matrix

$$= 10 + 11 + 12 + 50 + 20 = 103$$

Figure 6.4: Example of Matrix Calculation of Nonadditive Interactive Effects (Stull, et al., 1987a)

algebra. That is, the first element of the impact matrix is multiplied by the element in the first row and first column of the interaction matrix; the second element of the impact matrix is multiplied by the element in the second row and first column; and so on until all of the elements of the impact matrix have been multiplied by the corresponding elements of the first column of the interaction matrix. These products are summed to produce the first element of the product matrix. In a similar fashion, the elements of the impact matrix are multiplied by the elements of the remaining columns and the sums computed to produce the remaining elements of the product matrix. This product matrix will have the same dimensions as the impact matrix (e.g., acres of habitat loss).

It should be noted that the ITM allows for consideration of the cumulative effects of new projects (e.g., all five projects in Figure 6.4 are proposed), or new and existing projects (e.g., project 2 is new and projects 1, 3, 4, and 5 are existing), or new, existing and future projects (e.g., project 2 is new, projects 3, 4, and 5 are existing, and project 1 is planned for the future).

The final step in ITM (Step 7) is to consider the findings of the CEA in the planning and regulation of hydroelectric development in the Columbia River Basin. Such considerations could include different scenarios for current and future development projects, and their inclusion in both short-term and longer-term decisions.

In summary, the ITM is very flexible and can be applied to many different types of projects, species, and habitats. Impact and interaction information is displayed in a systematic and organized fashion that enables a quick determination of which projects have the greater single-project effects and which projects interact most strongly (and in which manner) with others. Reviews of the impact and interaction matrices can facilitate the analysis of different development scenarios (Stull, et al., 1987a). However, the ITM has some disadvantages. For example, there is the need for more data than is typically available. These data are required to build the models needed for estimations of effects on species or resources. Further, the ITM uses only first-order interactions (those between pairs of projects) to calculate the cumulative effect of multiple projects. Although higher-order interactions among projects may occur, the cost of accounting for these interactions would be great. Finally, with the ITM, the cumulative effects would need to be addressed for each of the species (resources) being considered. The ITM does not provide an approach for aggregating into one value the overall cumulative effect on all species (resources).

Irving and Bain (1993) described an application of the ITM within the CIAP for a study of cumulative effects on fish and wildlife from hydroelectric project development in the Salmon River Basin, Idaho. Using chinook salmon as the target species and five resource components for the species (spawning/incubation habitat, juvenile rearing habitat, adult holding habitat, migration/movement disruption, and sediment transport), an impact model was developed. Criteria for five impact levels were developed for the five components, and Table 6.13 summarizes the levels for three of the five components (Irving and Bain, 1993). Project interaction coefficients were also developed, with Table 6.14 depicting such coefficients for the migration/movement disruption component (Irving and Bain, 1993). In the developed model for chinook salmon, the total impact is calculated as follows (Irving and Bain, 1993):

Total impact = sum of project impacts ± interaction impacts

The computations for the total impact to chinook salmon considering three resource components and two projects are shown in Figure 6.5 (Irving

Table 6.13: Description of Impact Level Criteria for Three Chinook Salmon Resource Components: Spawning/Incubation, Juvenile Rearing, and Adult Holding Habitat[a] (Irving and Bain, 1993)

Impact Levels[b]	Description of Impact Levels[c]
4 (High)	>25% decrease in weighted usable area (WUA) or if WUA not available, then <30% of the mean annual flow
3 (Moderate)	>15-25% decrease in WUA or if WUA not available, then 30 to <60% (April-September) or 30-<40% (October-March) of the mean annual flow
2 (Low)	>5-15% decrease in WUA or if WUA not available, then 60 to <80% (April-September) and 40-<80% (October-March) of the mean annual flow
1 (Negligible)	>0-5% decrease in WUA or if WUA not available, then 80-100% of the mean annual flow
0 (None)	0% or an increase in WUA or if WUA not available, then 100 or >100% of the mean annual flow

[a] Weighted usable area and mean annual flows generated from the applicants' information can be used to assign the impact values (0, 1, 2, 3, or 4) for increasing levels of impact.

[b] When using the percentage of the mean annual flow, impacts levels were adjusted downward by 1 unit of impact (e.g., 3 to 2) if only a limited amount of anadromous fish habitat was available and by 2 if there was no or very little anadromous fish habitat present.

[c] Where possible, impact levels were assigned using information from approved instream flow modeling study results. If the study results were not available or not approved, then the percentage of the mean annual flow was used to assign impact levels.

Table 6.14: Interaction Coefficients and Criteria for the Migration/Movement Component of the Chinook Salmon Interaction Matrix (Irving and Bain, 1993)

Interaction Coefficient	Criteria
0.0	No project interaction on migration/movement of target resource
0.1	Project interaction on migration/movement possible but not likely to occur with negligible impact to target resource
0.5	Project interaction on migration/movement likely to occur with low to moderate potential impact to target resource
1.0	Project interaction on migration/movement likely to occur with high or severe potential impact to target resource

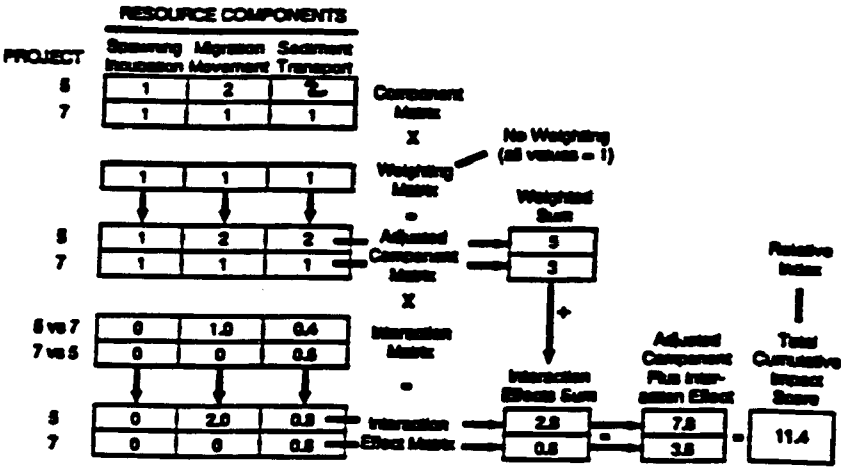


Figure 6.5: Example of Cumulative Impact Computations for a Target Resource with Three Resource Components and Two Projects (Irving and Bain, 1993)

and Bain, 1993). The same importance weights are shown for three resource components so the component matrix and adjusted component matrix are the same. The adjusted component matrix is summed across resources components to derive the weighted sums for each of the two projects. An interaction matrix was used to derive an interaction effects matrix, which is then summed across resources components to derive the interaction effects sum. The cumulative effects for each project are accounted for by adding the weighted and interaction effects sums. A total cumulative impact score is derived by adding across projects, and this score (11.4) can be used as a relative index of cumulative impact for the two-project configuration.

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CHAPTER 7

STRATEGIC ENVIRONMENTAL ASSESSMENT AND CUMULATIVE EFFECTS CONSIDERATIONS

Since its inception in the United States in 1970, the environmental impact assessment (EIA) process has been primarily applied to development projects proposed for specific locations; such applications will be referred to herein as project-level EIA. An emerging issue in the 1990s has been the application of the EIA process to policies, plans, and programs. The resulting documentations of these types of applications in the United States are called "programmatic environmental impact statements (EISs)"; the term being used internationally is strategic environmental assessment (SEA). This chapter summarizes the practices and experiences to date regarding SEA, including the incorporation of cumulative effects assessment (CEA). The majority of the assembled information was derived from publications generated outside the United States.

This chapter begins with definitions and concepts related to SEA, and the delineation of similarities and differences between SEAs and project-level EIAs used to generate project-oriented EISs (environmental impact statements). Examples of a variety of types of SEAs are then addressed. Substantive sections in this chapter are then devoted to planning a SEA and potentially useful methods for conducting a SEA and including CEA. The advantages and limitations (barriers) of SEA are then summarized along with several research needs. A conclusions section ends this chapter.

DEFINITIONS AND CONCEPTS

SEA refers to a systematic process for evaluating the direct, indirect, and cumulative environmental consequences of proposed policy, plan or program initiatives in order to ensure they are fully included and appropriately addressed at the earliest appropriate stage of decision making on par with economic and social considerations (Sadler and Verheem, 1996). In this context, policy refers to a general course of action or proposed overall direction that a government is, or will be, pursuing and which guides ongoing decision making. The definition of a plan is that it is a purposeful, forward-looking strategy or design, often with coordinated priorities, options and measures, that elaborates and implements policy. Finally, a program denotes a coherent, organized agenda or schedule of commitments, proposals, instruments and/or activities that elaborates and implements policy (Sadler and Verheem, 1996).

In an earlier publication, SEA was defined as the formalized systematic and comprehensive process of evaluating the environmental impacts of a policy, plan or program and its alternatives, including the preparation of a written report on the findings of that evaluation, and using the findings in publicly accountable decision-making (Therivel, et al., 1992). In this context, policies, plans, and programs are often referred to as PPPs (Therivel, et al., 1992).

Lee and Walsh (1992) suggested that two issues contributed to the growing interest in SEA in the late 1980s and early 1990s; they are: (1) a growing recognition that some important aspects of the EIA process, including attention to cumulative effects, cannot be satisfactorily

undertaken at the project evaluation stage and must, therefore, be carried out at earlier stages in the planning process; and (2) an increasing appreciation that the implementation of sustainable development strategies will require the use of EIA procedures and methods in the formulation of policies, plans and programs for the principal sectors of national economies.

From a broader perspective, Wood and Dejeddour (1992) identified the following four opportunities for more effective environmental planning which could be realized via the planning and conduction of SEAs:

(1) SEA can help give environmental concerns an importance similar to that of other aspects of development (e.g., economic, market requirement, financial and technological) in decisionmaking. It can encourage decisionmakers to articulate environmental goals along with social and economic goals.

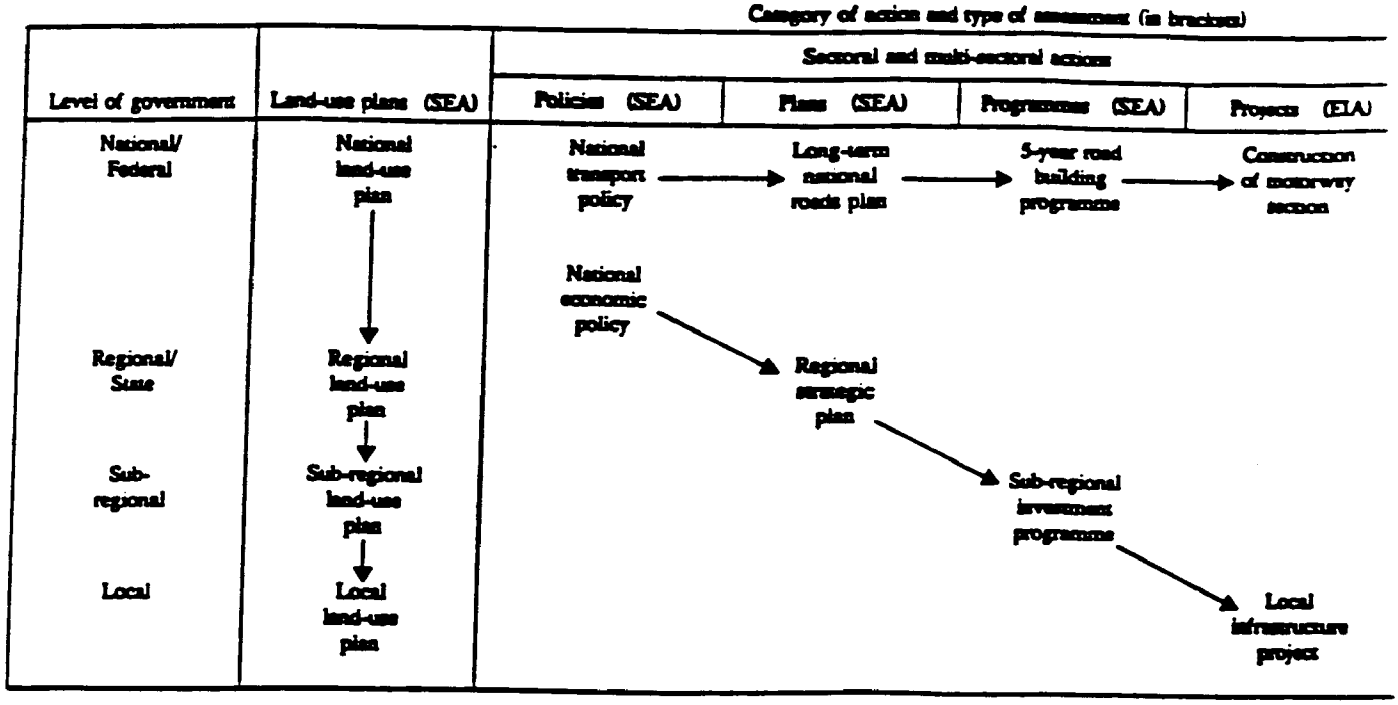
(2) SEA can facilitate and increase consultation on environmental aspects, including cumulative effects, between the many organizations generally involved in the formulation of policies, plans and programs. It also can provide the opportunity to determine the views of the general public on the nature of future developments which may concern them because of potential environmental implications. External scrutiny of proposals should itself result in greater public pressure for the integration of environmental concerns.

(3) In certain cases (e.g., some land-use plans), SEA may make project EIA redundant if impacts have been examined sufficiently at the plan or program level. In other cases, only a selected number of impacts may be examined, leaving others for the project stage.

(4) Principles regarding mitigation and compensation measures can be formulated for certain types of development as a result of SEA. These can be embodied in codes of conduct for various types of development.

Many types of PPPs could be subjected to SEAs. To facilitate consideration of this issue, a logical grouping of types of SEAs would be desirable. Accordingly, Therivel, et al. (1992) suggested that SEAs could be divided into three types: (1) sectoral; (2) regional; and (3) indirect. In some classifications, policy-related SEAs are delineated as a fourth type. Examples of sectoral SEAs include those for waste disposal, water supply, agriculture, forestry, energy, recreation, and transport. Regional SEA examples include those for regional plans, metropolitan/city plans, community plans, redevelopment plans, and rural plans. Examples of indirect SEAs include those for such "indirect" PPPs as science and technology, financial/fiscal policies, and justice/enforcement. Illustrations of specific concerns and case studies related to these types of SEAs are included in a subsequent section of this chapter.

SEAs should be considered within the overall context of impact studies related to PPPs and project-level EIA. To illustrate the relationships, Figure 7.1 depicts a tiered system of planning and environmental impact studies (Lee and Walsh, 1992). This system has general applicability; however, it should be recognized that it was developed based on land use and environmental planning practices in the United Kingdom.



N.B. This is a simplified representation of what, in reality, could be a more complex set of relationships. In general, those actions at the highest tier lev (e.g. national policies) are likely to require the broadest and least detailed form of strategic environmental assessment.

Figure 7.1: Actions and Assessments Within a Tiered Planning and Environmental Assessment System (Lee and Walsh, 1992).

Broader planning studies such as those related to sustainable development should also be considered in relation to SEAs. For example, Figure 7.2 depicts a variety of relationships between project-level EIA, CEA, SEA, land use planning and sustainability studies (Sadler and Verheem, 1996). The depicted linkages may vary from country-to-country; however, the primary point is that SEAs can be influenced by, and in turn, influence, other types of planning efforts and studies.

COMPARISONS OF SEAs AND PROJECT-LEVEL EIAs

There are several means by which SEAs and project-level EIAs can be compared. For example, Figure 7.3 delineates the principal stages in the SEA process and the project-level EIA process (Lee and Walsh, 1992). While many similarities exist, there are also distinctions; examples of such distinctions include:

(1) the scale of a SEA (in terms of action and related activities, range of considered alternatives, geographical area of study, and range of pertinent direct, indirect, and cumulative impacts) tends to be greater than that of an EIA;

(2) the time interval between conducting a SEA and implementation of specific activities is typically longer than for an EIA;

(3) the technical content and specificity of a SEA will be in lesser detail than for an EIA; and

(4) impact prediction uncertainties will be greater for a SEA than for an EIA.

As shown in Table 7.1, Wiseman (1996) has summarized several points of comparison between project-level EIA and SEA, including the perspective that CEA and sustainable development considerations are more appropriate for SEA. The overall impression given is that SEA is broader in scope and used for strategic planning, while project-level EIA addresses specific issues and impacts at specific locations. The relationships between these types of assessments and other topics such as environmental management systems and monitoring are shown in Figure 7.4 (Wiseman, 1996).

EXAMPLES OF SEA REQUIREMENTS AND SEAs

This section is intended to provide illustrations of countries with SEA requirements, and to identify various features and case studies related to several types of SEAs.

Institutional Requirements

Several countries or states within countries have either direct or indirect requirements related to SEAs; examples of states include Western Australia, South Australia, and California (Sadler and Verheem, 1996; McCarthy, 1996; and Bass and Herson, 1996). Examples of countries with requirements include Australia, Canada, The Netherlands, New Zealand, the United Kingdom, and the United States of America (Sadler and Verheem, 1996). The requirements can be based on legislation, administrative orders or directives, or advisory guidelines or operational policy. Table 7.2 lists examples of countries with direct or indirect SEA requirements; the identified references provide information on specific features of the requirements.

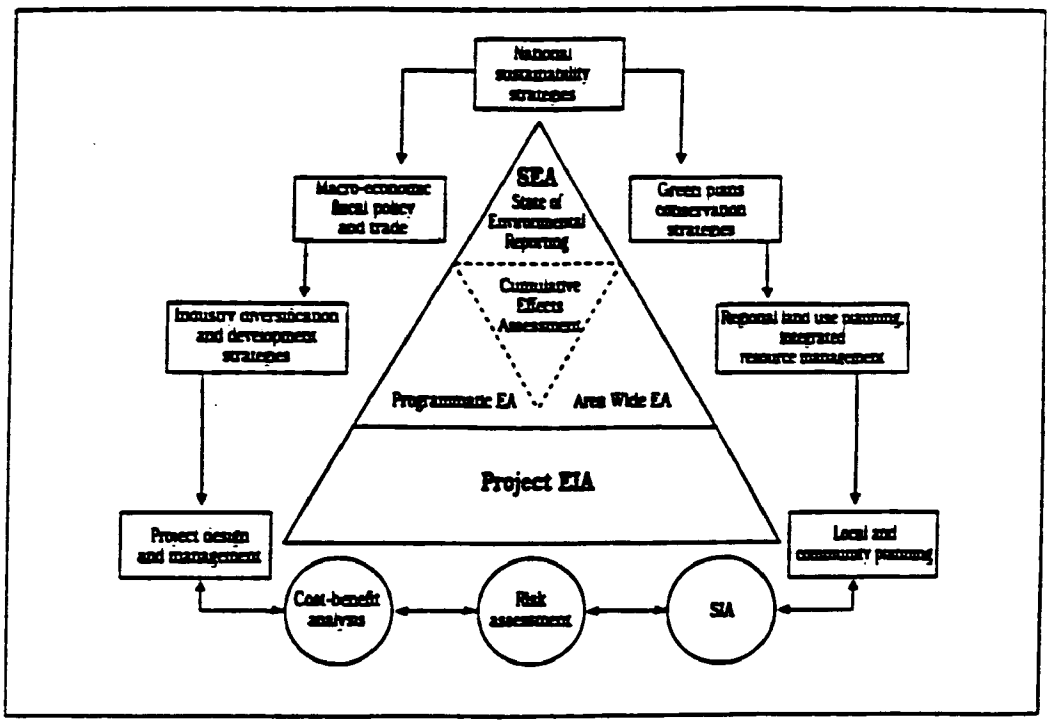


Figure 7.2: Linkages Between EIA, SEA, and Related Studies (Sadler and Verheem, 1996)

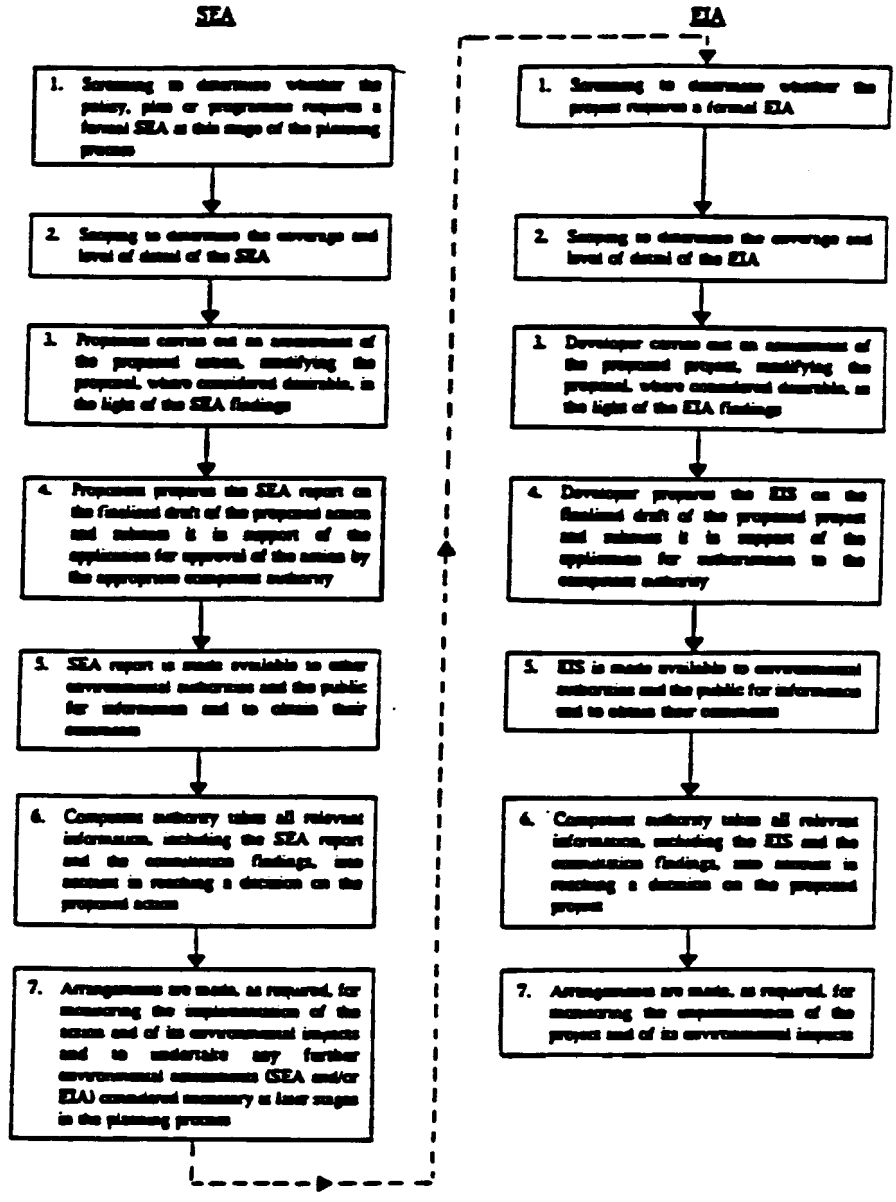


Figure 7.3: Comparison of the Principal Stages in the SEA and EIA Processes (Lee and Walsh, 1992)

Table 7.1: Comparative Features of Project-Level EIA and SEA (Wiseman, 1996)

EIA	SEA
Is reactive to a development proposal	Is pro-active and informs development proposals
Assesses the effect of a proposed development on the environment	Assess the effect of the environment on development needs and opportunities (constraints)
Addresses a specific project	Addresses area, regions or sectors of development
Has a well defined beginning and end	Is a continuing process aimed at providing information at the right time
Assesses direct impacts and benefits	Assesses cumulative impacts and identifies implications and issues for sustainable development
Focused on the mitigation of impacts	Focused on maintaining a chosen level of environmental quality
Narrow perspective and a high level of detail	Wide perspective and a low level of detail to provide a vision and overall framework
Focus on project-specific impacts	Creates a framework against which impacts and benefits can be measured

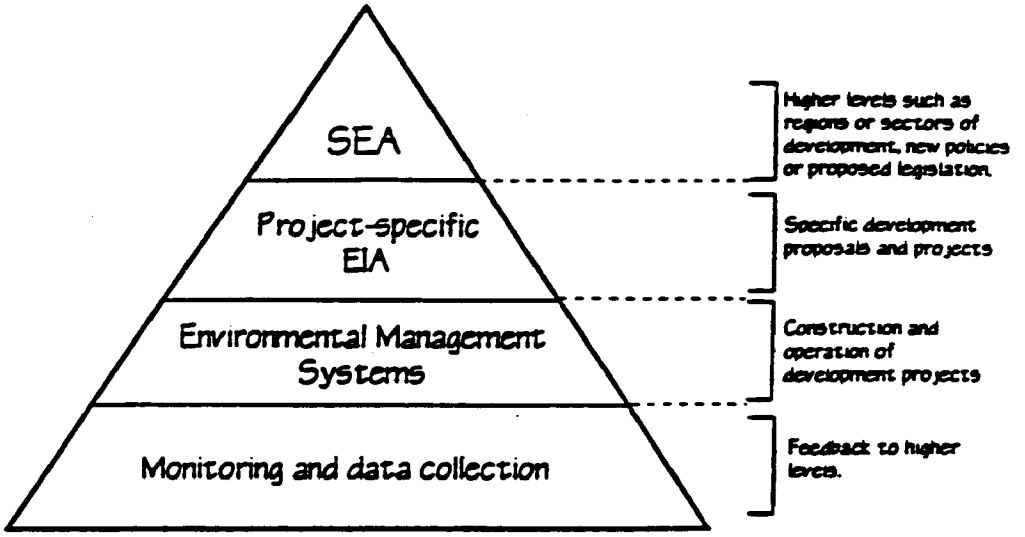


Figure 7.4: **Relationships Between SEA and Project-Specific Activities (Wiseman, 1996)**

Table 7.2: Examples of Countries with SEA Requirements

Country	Reference
Australia	Wood (1992) Partidario (1996)
Canada	Partidario (1996) Sadler and Verheem (1996)
Denmark	Partidario (1996) Sadler and Verheem (1996)
European Commission (12 member countries)	Sadler and Verheem (1996)
Finland	Partidario (1996)
France	Partidario (1996)
Germany	Therivel, et al. (1992) Partidario (1996)
Greece	Therivel, et al. (1992)
Hong Kong	Hong Kong Government (1995) Sadler and Verheem (1996)
Ireland	Therivel, et al. (1992)
Italy	Therivel, et al. (1992)
Luxembourg	Therivel, et al. (1992)
The Netherlands	Verheem (1992) Therivel, et al. (1992) Partidario (1996) Sadler and Verheem (1996)
New Zealand	Wood (1992) Partidario (1996) Sadler and Verheem (1996)
Portugal	Therivel, et al. (1992)
Spain	Therivel, et al. (1992)
Sweden	Partidario (1996)
United Kingdom	Therivel, et al. (1992) Partidario (1996) Sadler and Verheem (1996)
United States of America	Sigal and Webb (1989) Webb and Sigal (1992) Bass and Herson (1996) Partidario (1996) Sadler and Verheem (1996)

Policy-focused SEAs

A workshop was held in The Netherlands in late 1994 for the purpose of discussing experiences related to SEAs of policies (de Boer and Sadler, 1996). Collective experiences from Canada (Le Blanc and Fischer, 1996), Denmark (Elling, 1996; and Johansen, 1996), the European Commission (Norris, 1996), Hong Kong (Law, 1996), The Netherlands (de Vries, 1996), New Zealand (Gow, 1996), and Western Australia (Sippe, 1996) were summarized and discussed relative to both the advantages and limitations of SEAs of policies. An alternate name for a policy-focused SEA is a policy impact assessment (PIA) (Boothroyd, 1995).

The following objectives have been identified for policy-focused SEAs (Therivel, et al., 1992):

(1) to ensure the full consideration of alternative policy options, including the 'do-nothing' option, at an early time when an agency has greater flexibility;

(2) to enable consistency to be developed across different policy sectors, especially where trade-offs need to be made between objectives;

(3) to ensure that the cumulative, indirect or secondary impacts of diverse multiple activities are considered, including their unintended consequences;

(4) to enable adverse environmental impacts to be anticipated and hence avoided or prevented;

(5) to ensure that the environmental impact of policies that do not have an overt environmental dimension is assessed;

(6) to obviate the needless reassessment of issues and impacts at the project level where such issues could more effectively be dealt with at a strategic level, and offer time and cost savings;

(7) to provide a publicly available and accountable decision-making framework;

(8) to ensure that environmental principles such as sustainability and the precautionary principle are integrated into the development, appraisal and selection of policy options; and

(9) to give a proper place to environmental considerations in decision-making *vis-á-vis* economic and social concerns, given that in some contexts they may be traded off against each other.

Sectoral-focused SEAs

Examples of sectoral-focused SEAs include those related to national (or regional) energy plans, irrigation schemes, agricultural productivity enhancement programs, transportation plans, coal or other mineral mining strategies, oil and/or gas development activities, and waste management efforts.

The World Bank has utilized sectoral SEAs in the context of loan applications for sector investment programs involving multiple sub-projects. Sectoral environmental assessments within World Bank usage are

conceptually similar to programmatic EISs in the United States (World Bank, 1991). Examples of the potential advantages of such SEAs include (World Bank, 1993):

(1) Sectoral SEAs can prevent serious environmental impacts through analysis of sector policies and investment strategies upstream in the planning process, before major decisions are made.

(2) They can assist governments in forming a long-term view of the sector and can increase the transparency of the sectoral planning process (that is, show the reasoning behind development plans), thereby decreasing the opportunities for purely political decisions that might be environmentally harmful.

(3) They provide opportunities for consideration of alternative policies, plans, strategies or project types, taking into account their costs and benefits.

(4) Sectoral SEAs can help to alter or eliminate environmentally unsound investment alternatives at an early stage, thus reducing overall negative environmental impacts.

(5) They are well-suited to consider cumulative effects of multiple ongoing and planned investments within a sector, as well as impacts from existing policies and policy changes.

(6) They are valuable for collecting and organizing environmental data into information and, in the process, identifying data gaps and needs at an early stage, and for outlining methods, schedules and responsibilities for data collection and management during program or project implementation.

(7) They allow for comprehensive planning of general sector-wide mitigation, management, and monitoring measures, and for identifying broad institutional, resource and technological needs at an early stage.

The topics which should be addressed in a sectoral SEA prepared for the World Bank are listed in Table 7.3 (World Bank, 1993).

Geographically-focused SEAs

The World Bank has suggested that Regional Environmental Assessments (REAs) (another name for SEAs) can be useful for development planners in designing investment strategies, programs and projects that are environmentally sustainable (World Bank, 1996). The focus is on environmental issues and impacts in a distinctly spatial setting. Examples of regions include river basins, airsheds, mountainous areas, forested areas, coastal zones, islands, and urban areas.

To illustrate one type of region, coastal areas can be exploited for food, energy, and material resources. Land uses near the coastal zone should be planned to minimize undesirable impacts to area resources, while also allowing for tourism and other appropriate economic developments. These planning efforts can be facilitated by the conduction of SEAs focused on defined geographical areas encompassing both land and water resources; the World Bank refers to these SEAs as Regional Environmental Assessments (World Bank, 1994). The SEAs can be complementary and

Table 7.3: Topics to be Addressed in a World Bank Sectoral SEA (World Bank, 1993)

Executive Summary. As in a project-specific EIA, a SEA should contain an executive summary, with a concise discussion of significant findings and recommended actions.

Policy, Legal and Administrative Framework. This section is one of the most important parts of a sectoral SEA. It is helpful to analyze both (1) the national environmental legal, regulatory and institutional framework, and (2) sector-specific policies, regulations and institutions.

- The national framework. The relevant national environmental policies, laws and regulations should be assessed for completeness and appropriateness in light of the particular conditions and problems of the sector, and gaps and weaknesses noted. Non-environmental laws and policies that have significance for the sector's utilization of resources, production processes, or pollution should also be identified. Similarly, the national regulatory framework for EIA preparation and review should be assessed. The SEA should look closely at the institutional capacity of the main environmental ministry or agency, in terms of effectiveness and capacity for providing guidelines, setting and enforcing standards, and reviewing environmental assessments. The capacity and performance of agencies responsible for specific environmental services such as nature protection and cultural heritage should also be reviewed when relevant.

- The sector framework. The SEA should analyze sector-specific policies, laws and regulations that have environmental implications. It should also identify how environmental responsibilities are distributed among (public or private) sector institutions and assess their capacity to administer these tasks. The sectoral investment planning process, in terms of objectives, methodology and procedures for review and approval of plans and projects, should be carefully reviewed. The relationship between timing of project review, issuance of licenses and permits, and the sectoral planning process should be clearly indicated. The SEA should assess whether environmental and social issues are adequately covered by current procedures.

Project Description. The nature and objectives of the program, plan, series of projects or other context to which the SEA is attached should be described, and the main environmental issues associated with the sector and these programs, identified.

Baseline Data. This section should describe and evaluate the current environmental situation in the sector. Where a project-specific EIA would describe conditions such as ambient air and water quality or existing impacts from pollution around a proposed project site, the SEA should concentrate on the issues and problems that are typical of the sector as a whole. For example, occupational health may be a concern across enterprises within a specific industry; seepage of heavy metals into streams and groundwater may be a recurring problem in the mining sector; or deforestation may result from activities in the agriculture sector. Another important function of this section is to note major data gaps.

Environmental Impacts. The single most difficult challenge in SEAs is to produce a sufficiently precise impact analysis, often in the face of uncertainties related to the final investment decisions and their individual and combined impacts. In recent years, advances have been made in the methodologies for assessing cumulative impacts, in relation to development plans and programs. Means include quantitative modeling, forecasting and various qualitative analyses. If any proposed sub-project is expected to cause particularly significant impacts, the SEA should recommend an appropriate course of action to address them, including carrying out a project-specific EIA.

All cumulative effects should be considered: positive and negative, direct and indirect, long-term and short-term. Aggregate problems such as sewage discharge, acid rain, ozone depletion and deforestation are usually the result of several activities, sometimes stemming predominantly from a single sector. Cumulative impacts on environmentally important and sensitive areas and assets such as coastal zones and wetlands, or freshwater resources, are also important in cases where the sector activities heavily affect these areas and/or resources.

The sectoral SEA is an appropriate instrument for considering issues related to long-term sustainable development. Specifically, the SEA may contain a discussion of how a proposed investment program may influence long-term productivity of environmental resources affected by the program.

Analysis of Alternatives. A major purpose of a SEA is to do a thorough analysis of alternative investment options and strategies in terms of environmental costs and benefits. The sectoral SEA can also be used to evaluate the environmental effects of sector policy alternatives. For example, changes in tax and subsidy rates on the use of natural resources may greatly influence rates and methods of extraction.

Table 7.3 (continued):

The analysis could conclude with a list of sector proposals, ranked according to environmental preference. The analysis of impacts and alternatives should result in a recommendation for an optimal investment strategy, in terms of environmental and social costs and benefits.

Mitigation Plan. Mitigation measures are usually of a detailed, technical nature, and therefore, normally addressed in project-specific EIAs. However, if planned or existing production and process technologies in a sector are relatively uniform, the SEA could recommend broad options for eliminating, reducing to acceptable levels, or mitigating environmental impacts. Such solutions could include a complete production system design as well as end-of-pipe cleaning technologies. SEA mitigation recommendations should draw on findings from the analysis of policy, legal and institutional issues as well as the analysis of impacts and alternatives.

Environmental Management and Training. One of the main outputs of a SEA should be an institutional plan for improving environmental management in the sector, based on findings of the previous sections. The plan might recommend training of existing staff, hiring of additional staff, reorganization of units or agencies, or redefinition of roles and responsibilities.

Environmental Monitoring Plan. The SEA should provide general guidelines for long-term sector-wide environmental monitoring to ensure adequate implementation of investments. A monitoring plan should use the findings of the baseline data section as a basis to measure progress in mid-term review and final evaluation. The plan should also recommend measures needed to collect and organize missing data.

Public Consultation. Public consultation is an integral part of the EIA process, whether a project-specific or sectoral EIA is being prepared.

supportive of coastal zone management plans (or planning efforts). Of particular concern in SEAs may be detrimental impacts or unique ecosystems such as coral reefs, coastal wetlands, mangrove areas, seagrasses, muddy and sandy bottoms, and rocky coasts (World Bank, 1994).

Some useful purposes which can be accomplished through the planning and conduction of regional environmental assessments are (World Bank, 1991):

(1) the definition of study areas in terms which make environmental sense (e.g., river basin, airshed, coastal zone);

(2) selection of sustainable development patterns from alternatives in a region under development pressure (e.g., the coastal zone), or being programmed for development for the first time;

(3) identification of cumulative effects of different activities, and design or implementation of schedule changes and other measures to avoid or mitigate them;

(4) identification of environmental interactions or conflicting demands on resources among projects in which the impacts of one project may reduce the benefits of another, and of measures to avoid such a result;

(5) formulation of criteria for environmentally sustainable development in the region, including treatment of environmentally sensitive areas and resources, site selection criteria, design criteria, region-specific measures to mitigate adverse impacts, and land-use planning guidelines;

(6) identification of monitoring data needs and definition of data collection programs to support EIA, CEA, and development decisions; and

(7) examination of policy alternatives and institutional elements needed for achieving sustainable development in the region.

Examples of potential benefits of REAs include (World Bank, 1996):

(1) provide a baseline overview of environmental conditions within the study area (a regional "state of the environment"), which is key to making reliable assessments of direct, indirect, and cumulative effects and monitoring environmental changes over time;

(2) assist governments in forming a long-term view of regional planning and increase the transparency of the planning process, thereby modifying or eliminating decisions that might be individually or cumulatively harmful to the environment;

(3) analyze the institutional and legal framework relevant to the particular region, identify institutional and jurisdictional gaps, and make recommendations regarding, for example, environmental standards and law enforcement appropriate for the region;

(4) suitably collect and organize regional environmental data and, in the process, identify data gaps and needs at an early stage, and outline methods, schedules and responsibilities for

data collection and management during program or project implementation;

(5) allow for comprehensive planning of region-wide environmental management and monitoring, and identify broad institutional, resource and technological needs at an early stage, including potential funding problems;

(6) provide a basis for collaboration and coordination across administrative boundaries and between sector-specific authorities and help avoid contradictions in policy and planning while enhancing efficiencies;

(7) strengthen preparation and implementation of individual projects within the region, by recommending criteria for environmental screening, analysis and review of such projects, and setting standards and guidelines for project implementation; and

(8) provide a vehicle for public participation in shaping the future development of a region, thereby building public support for the process.

Programmatic EISs in the United States

In the United States the Council on Environmental Quality (CEQ) Regulations contain concepts and definitions related to EIA. The Regulations also include the concepts of SEA, although the focus is on what are called "programmatic EISs" and "tiering." Fundamentally, EISs are required on major federal actions; such actions can include policies, plans, and programs. For example, para. 1508.18(b) indicates that federal actions tend to fall within one of the following categories (Council on Environmental Quality, 1987):

(1) Adoption of official policy, such as rules, regulations, and interpretations; treaties and international conventions or agreements; or formal documents establishing an agency's policies which will result in or substantially alter agency programs.

(2) Adoption of formal plans, such as official documents prepared or approved by federal agencies which guide or prescribe alternative uses of federal resources, and upon which future agency actions will be based.

(3) Adoption of programs, such as a group of concerted actions to implement a specific policy or plan; or systematic and connected agency decisions allocating agency resources to implement a specific statutory program or executive directive.

(4) Approval of specific projects, such as construction or management activities located in a defined geographic area. Projects include actions approved by permit or other regulatory decisions as well as federal and federally assisted activities.

SEA or "programmatic EISs" would apply to (1) through (3) above, and project-level EIA would apply to (4). Programmatic EISs are related to project-level EISs via tiering. Tiering is defined in the CEQ Regulations in para. 1508.28 as (Council on Environmental Quality, 1987):

The coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basinwide program statements or ultimately site-specific statements) incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared. Tiering is appropriate when the sequence of statements or analyses is:

(a) From a program, plan, or policy environmental impact statement to a program, plan, or policy statement or analysis of lesser scope or to a site-specific statement or analysis.

(b) From an environmental impact statement on a specific action at an early stage (such as need and site selection) to a supplement (which is preferred) or a subsequent statement or analysis at a later stage (such as environmental mitigation). Tiering in such cases is appropriate when it helps the lead agency to focus on the issues which are ripe for decision and exclude from consideration issues already decided or not yet ripe.

The concept of tiering is addressed in para. 1502.20 as follows (Council on Environmental Quality, 1987):

Agencies are encouraged to tier their environmental impact statements to eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review. Whenever a broad environmental impact statement has been prepared (such as a program or policy statement) and a subsequent statement or environmental assessment is then prepared on an action included within the entire program or policy (such as a site specific action) the subsequent statement or environmental assessment need only summarize the issues discussed in the broader statement and incorporate discussions from the broader statement by reference and shall concentrate on the issues specific to the subsequent action. The subsequent document shall state where the earlier document is available. Tiering may also be appropriate for different stages of actions.

If properly done in a timely manner, tiering can aid in the reduction of paperwork.

Para. 1502.4(c) further suggests an approach for grouping broad actions to be addressed by a programmatic EIS; this approach, which includes several concepts related to CEAs, is as follows (Council on Environmental Quality, 1987):

When preparing statements on broad actions (including proposals by more than one agency), agencies may find it useful to evaluate the proposal(s) in one of the following ways:

(1) Geographically, including actions occurring in the same general location, such as body of water, region, or metropolitan area.

(2) Generically, including actions which have relevant similarities, such as common timing, impacts,

alternatives, methods of implementation, media, or subject matter.

(3) By stage of technological development including federal or federally assisted research, development or demonstration programs for new technologies which, if applied, could significantly affect the quality of the human environment. Statements shall be prepared on such programs and shall be available before the program has reached a stage of investment or commitment to implementation likely to determine subsequent development or restrict later alternatives.

One rather unique topic related to SEA and addressed by the CEQ Regulations is associated with EISs on proposed legislation. Such legislative impact studies should incorporate the consideration of direct, indirect, and cumulative effects. This topic is described in para. 1506.8(a) as follows (Council on Environmental Quality, 1987):

> The NEPA process for proposals for legislation significantly affecting the quality of the human environment shall be integrated with the legislative process of the Congress. A legislative environmental impact statement is the detailed statement required by law to be included in a recommendation or report on a legislative proposal to Congress. A legislative environmental impact statement shall be considered part of the formal transmittal of a legislative proposal to Congress; however, it may be transmitted to Congress up to 30 days later in order to allow time for completion of an accurate statement which can serve as the basis for public and Congressional debate. The statement must be available in time for Congressional hearings and deliberations.

Table 7.4 illustrates the types of policy, plan, or program subjected to the preparation of a programmatic EIS in the United States in 1994 (Bass and Herson, 1996). Geographical plans for various land uses were the most common types of actions subjected to such strategic impact studies. Programmatic EISs represented about 25% of all EISs prepared in the United States in 1994. Although no specific review of these programmatic EISs has been done regarding their inclusion of CEAs, it can be presumed that most, if not all, incorporated cumulative effects considerations.

Case Studies

Ten case studies related to SEAs are in a recent book (Therivel and Partidario, 1996a); they are focused on the context and utilized steps, and their results and perceived effectiveness (Therivel and Partidario, 1996b). These case studies, along with several others, are identified in Table 7.5. Again, it can be presumed that these case studies incorporated cumulative effects considerations.

PLANNING AND IMPLEMENTATION OF SEAs

The planning and implementation of a SEA involves the consideration of a number of issues. As shown earlier in Figure 7.3, the stages of a SEA have some similarities and some differences in relation to the stages in a project-level EIA. Sadler and Verheem (1996) have suggested that

Table 7.4: Programmatic EISs Prepared by Federal Agencies in the United States -- January 1994 - December 1994 (Bass and Herson, 1996)

Type of Plan, Policy or Program	Number of EISs
Military base reuse plans (BRAC)	25
River basin plans (e.g., wild & scenic designation, flood control, ecosystem management, water quality)	19
Public land management plans	17
National park management plans	15
National forest management plans	13
Fishery management plans	10
Wildlife habitat management plans	7
National wildlife refuge plans	3
Nuclear fuel management plans	4
Energy, utility or fuel management plans (non-nuclear)	3
Hydroelectric power programs (multi-facility systems)	2
Pest management plans	2
Mineral management plan	1
Dredge disposal plan	1
Air quality emissions standards	1
National border enforcement program	1
Range land reform program	1
Solid waste management plan	1
Oil spill habitat restoration plan	1
Regional aircraft flight management plan	1
Total	128

Table 7.5: Case Studies Related to SEA

Category of Action		Reference
(A)*	Land use planning in the United Kingdom	Pinfield (1992)
(A)	Territorial development strategy in Hong Kong	Hong Kong Government (1995)
(A)	Land use planning in Hertfordshire County in the United Kingdom	Rumble and Therivel (1996)*
(A)	Municipal land use planning in Sweden	Asplund and Hilding-Rydevik (1996)*
(A)	Land use planning in San Joaquin County in California in the United States of America	Skewes-Cox (1996)*
(S)	Water environment in the United Kingdom	Gardiner (1992)
(S)	Transportation sector in the United Kingdom	Sheate (1992)
(S)	Siting of windfarms in Germany	Kleinschmidt and Wagner (1996)*
(S)	Forest management plan in Nepal	Khadka, et al., (1996)*
(S)	National level environmental restoration and waste management program in the United States of America	Webb and Sigal (1996)*
(S)	Trans-European rail network	Dom (1996)*
(S)	National waste management program in The Netherlands	Verheem (1996)*
(P)	Allocation of funds for economic development in Europe	Bradley (1996)*
(P)	Crop insurance policy in Canada	Campbell (1996)*

A = area-wide or geographical SEA
S = sector-based SEA
P = policy-based SEA
*case study in Therivel and Partidario (1996a)

"good practice" regarding SEA should incorporate the following items within the utilized framework:

(1) Apply a simple screening procedure to initiate SEA or exempt proposals from further consideration, depending on their consequentiality. Several methods can be used: categorical lists, case-by-case test for significance, some combination, or, where no formal guidance is available, prescreening questions.

(2) Use scoping to identify important issues (including cumulative effects), draft terms of reference where necessary for SEA, determine the approach to be followed, and establish other alternatives for consideration.

(3) Specify, evaluate and compare alternatives, including the no action option. The aim is to clarify the trade-offs at stake, showing what is gained or lost, and point, where possible, to the best practicable environmental option (or equivalent designation).

(4) Conduct a policy appraisal or impact analysis to the extent necessary to examine environmental issues and cumulative effects, compare the alternatives, and identify any necessary mitigation or offset measures for residual concerns.

(5) Report the findings of the SEA, with supporting advice and recommendations, to decision makers in clear and concise language. Depending on the proposal, the documentation may range from a few pages to an EIS; longer reports should have an executive summary.

(6) Review the quality of the SEA to ensure the information is sufficient, and relevant to requirements of decision making. Depending on the process, this activity can range from a quick check to an independent review.

(7) Establish necessary follow up provisions for monitoring effects, checking that environmental conditionalities are being implemented, and, where necessary, tracking arrangements for project EIAs. For policies, plans and programs that initiate projects, tiering EIA to the SEA can significantly improve process effectiveness and efficiency.

Table 7.6 summarizes a methodology developed in 1981 by the U.S. Department of Housing and Urban Development for assessing the impacts of alternative patterns of urban development or redevelopment in metropolitan-scale areas (Therivel, et al., 1992). The listed general topics could be used to plan any type of geographically-focused SEA; they could also serve as a basis for developing the topical contents of an areawide EIS (geographically-based SEA). Further, cumulative effects considerations could be incorporated into topics (2) through (7).

Detailed considerations will not be given herein to each issue related to planning a SEA; rather, particular attention will be given to indicators, alternatives, mitigation measures, and the potential topical contents of a SEA report.

Table 7.6: Topical Issues in an Area-Wide Study of Urban Development or Redevelopment (Therivel, et al., 1992)

(1) Determine need/feasibility:
indicators of need;
availability of data, expertise, funds;
prepare study design.

(2) Establish area boundaries, analysis units, environmental data base:
availability of data;
location of expected change;
location of resources/hazards;
jurisdictional boundaries;
compatibility with anticipated impact issues.

(3) Identify areawide alternatives:
research local and areawide plans, programs, etc.;
define areawide alternatives: totals, 'theme,' etc.;
allocate areawide totals to analysis units:
by land use type, resource type, etc.

(4) Scoping:
identify key issues;
eliminate nonpertinent issues;
establish work plan: revise/finalize area boundaries, data collection plan, report format.

(5) Environmental analysis:
document baseline conditions (analysis unit scale): presence or absence, quantity, sensitivity/significance, trends, past changes if significant;
establish units or multipliers of demand and/or consumption (per capita, per household, by industry, etc.);
estimate impacts: for each environmental component and for each alternative begin at analysis unit scale, aggregate for area scale.

(6) Impact synthesis and evaluation:
identify evaluation standards/criteria/preferences;
evaluate impacts for each environmental component;
compare alternatives.

(7) Recommendations:
identify mitigation measures (prevention, compensation, substitution);
identify preferred alternative (if possible).

Indicators

Indicators can be used within SEAs as a means of describing existing environmental conditions, predicting impacts, and comparing alternatives. Criteria which can be used for choosing such indicators, including cumulative effects indicators, include that they (Therivel, 1996):

(1) are individually and collectively meaningful;

(2) represent key issues;

(3) reflect both national/regional interests and local trends;

(4) are based on valid principles and assumptions;

(5) are based on relatively easy to collect information, preferably information that has already been available over a reasonable time-scale;

(6) allow qualitative and quantitative information, and information at different spatial scales, to be used in a methodologically sound way;

(7) allow consideration of alternatives, both separately and in combination;

(8) lead to the measurement of baseline information and the prediction and monitoring of impacts;

(9) yield results that are repeatable given certain explicit assumptions;

(10) stimulate the imagination of decision-makers and increase insight into the choices to be made; and

(11) yield results that are understandable to decision-makers and the public.

Alternatives

The alternatives addressed in PPPs can be broader and perhaps of a different nature than typical alternatives for project-level EIAs. In fact, such alternatives can be compared and evaluated relative to their features regarding cumulative effects. Examples of PPP-specific alternatives include (Therivel, 1996):

(1) the 'do nothing' or 'continue with present trends' option;

(2) demand reduction, for instance reducing the demand for water through water metering, as well as meeting demand;

(3) different locational approaches, for instance building new houses in existing towns or in new towns;

(4) provision of different types of development which achieve the same objective, for instance producing energy by gas, coal, wind, etc.;

(5) fiscal measures such as toll roads or congestion charges;

(6) different forms of management, for instance waste management by recycling, incineration, etc.; and

(7) combinations of development and management approaches which exemplify themes, such as more public vs. more car transport.

Mitigation Measures

Potential mitigation measures which can be appropriate in SEAs, including measures to minimize undesirable cumulative effects, include (Therivel, 1996):

(1) planning future developments to avoid sensitive sites;

(2) placing constraints on, or establishing a framework for, lower-tier PPPs; this could include requirements for SEA/EIA of lower-tier PPPs and projects, or specific requirements for the implementation of projects resulting from the PPP;

(3) establishing or funding the establishment of, new areas of nature conservation or recreation;

(4) establishing management guidelines for the implementation of the PPP; and

(5) relocating sensitive/rare wildlife species or habitats, or local amenities.

Contents of SEA Reports

Two examples of report contents will be mentioned. First, in 1992 a potential list of topics which should be addressed in a SEA report (or programmatic EIS) was promulgated; the topics are as follows (Wood and Dejeddour, 1992):

(1) a description of the policy, plan or program and its main objectives;

(2) a description of how the effects (direct, indirect, and/or cumulative) on the environment were taken into account in formulating the objectives of the policy, plan or program;

(3) a description of the main alternatives;

(4) a description of the aspects of the environment and, where possible, of the area likely to be affected, including a description of sensitive zones;

(5) a description of the likely significant direct, indirect, and cumulative effects of the policy, plan or program and its main alternatives on the environment;

(6) a description of mitigation measures for the chosen alternative, including the procedures which will apply to the evaluation of lower tier actions following from the action;

(7) a description of the compatibility of the chosen alternative with relevant environmental regulations;

(8) an outline of the difficulties (technical deficiencies or lack of knowledge) encountered in compiling the required information; and,

(9) a non-technical summary.

Therivel, et al. (1992) also suggested a topical outline for a SEA report as including the following:

(1) table of contents;

(2) summary;

(3) description of proposed PPP and its objectives;

(4) description of the need for, and feasibility of, the PPP;

(5) alternatives to the PPP;

(6) description of 'boundaries' -- regional or sectoral -- that form the limits of the SEA (it should be noted that delineating such boundaries is also appropriate in CEAs);

(7) relation to other relevant PPPs (could include cumulative effects considerations) and environmental requirements;

(8) scoping of issues/impacts to which the SEA is limited (including a statement explaining why other possible issues/impacts are not addressed), such scoping could be focused on cumulative effects;

(9) description of affected environment;

(10) environmental consequences (direct, indirect, and cumulative) of the proposed PPP and alternatives;

(11) impact evaluation;

(12) proposed mitigation measures;

(13) recommendations; and

(14) list of preparers and recipients.

General Principles for Implementing SEAs

Finally, regarding the implementation of SEAs, 12 general principles have been articulated as follows (Sadler and Verheem, 1996):

(1) initiating agencies are accountable for assessing the environmental effects (direct, indirect, and cumulative) of new or amended policies, plans and programs;

(2) the assessment process should be applied as early as possible in proposal design;

(3) the scope of assessment must be commensurate with the proposal's potential impact or consequence for the environment (the scope could focus on cumulative effects);

(4) objectives and terms of reference should be clearly defined;

(5) alternatives to, as well as the direct, indirect, and cumulative environmental effects of, a proposal should be considered;

(6) other factors, including socio-economic considerations, should be included as necessary and appropriate;

(7) evaluation of significance and determination of acceptability should be made against a policy framework of environmental objectives and standards;

(8) provision should be made for public involvement, consistent with the potential degree of concern and controversy of the proposal;

(9) public reporting of the assessment and decisions (unless explicit, stated limitations on confidentiality are given);

(10) need for independent oversight of process implementation, agency compliance and government-wide performance;

(11) SEA should result in incorporation of environmental factors, including cumulative effects consideration and sustainable development, in policy making; and

(12) tiered to other SEAs, project EIAs and/or monitoring for proposals that initiate further actions (implied in such tiering is the consideration of cumulative effects).

METHODS FOR USE IN SEAs

A number of types of methods can be useful within the context of the tasks associated with a SEA. To illustrate, Table 7.7 contains an early list of applicable methods tied to specific tasks (Wood and Dejeddour, 1992).

Applicable methods for SEA include the types of methods listed in Table 5.2 herein for project-level EIAs, as well as methods typically used for policy analysis/plan evaluation (Sadler and Verheem, 1996). Examples of the latter group of methods include scenarios, planning balance sheets, and cost-benefit analysis. Depending upon the particular characteristics of the policy, plan, or program subjected to SEA, modifications may be necessary in selected methods from both groups. Table 7.8 lists some specific methods which can be used for impact identification in SEA, including the identification of cumulative effects; the methods are displayed in four categories (Sadler and Verheem, 1996). Examples of methods which can be used for impact analysis in SEA are shown in Table 7.9 (Sadler and Verheem, 1996).

Table 7.10 delineates examples of methods associated with different steps in planning and conducting a SEA (Sadler and Verheem, 1996). As was noted earlier in conjunction with applying the EIA process to project-level actions, no single method can be used to fulfill all the steps in a SEA.

One aspect of impact analysis involves impact prediction. Examples of impact prediction techniques which can be used in SEAs include (Therivel, 1996):

Table 7.7: Potentially Applicable Methods Associated with SEA Tasks (Wood and Dejeddour, 1992)

TASK	METHODS (EXAMPLES ONLY)
Deciding if SEA is necessary	Use of prescriptive lists, guidelines, thresholds and criteria; determination of local environmental significance; authority and public consultations.
Description of the action and the environment affected	Checklists; matrices; networks; aerial photography; cartographic techniques; field and random sampling techniques; data collation and retrieval systems; review of existing monitoring systems; consultations
Impact identification, scoping and screening	Legislative requirements; screening criteria; guidelines; simple checklists; matrices; networks; energy flow diagrams and simulation models; comparisons with similar studies and use of case studies; preliminary impact prediction.
Predicting impacts	Population and economic forecasting techniques (e.g., input-output analysis; simulation, computer and diffusions models; expert systems; dose-response functions).
Determination of impact significance	Public and environmental agency consultations (e.g., Delphi method, public hearings, social surveys, etc.); use of significance criteria and standards; scaling and weighting systems; overlay methods.
Description of mitigating measures	Consideration and description of mitigating measures for each alternative.
Evaluation of alternatives	Cost-benefit analysis; goals achievement matrix; planning balance sheet; scaling and weighting systems; overlays; simulation models; worst case analysis; application of evaluation criteria.
Determining compatibility with environmental regulations	Review of existing relevant environmental legislation; environmental and other agency consultations.
Reporting assessment findings	Overlays; mapping; photomontages; models; matrices; summary sheets.
Reviewing the report	Competent authority checklists; review criteria; consultations.
Consultation and public participation	Social survey techniques; public consultations by means of hearings, meetings, seminars, etc.; agency consultation (Delphi Method, meetings, etc.)
Synthesizing consultation findings and decisionmaking	Synthesis and analysis of the results of consultation (use of summary sheets; matrices, etc.); application of evaluation criteria; action modification in the light of these.
Implementation, monitoring and post-auditing	Application of evaluation criteria and use of guidelines; consultation and public participation; environmental monitoring systems (similar methods as those used to describe the existing environment).

Table 7.8: Some Methods for Impact Identification in SEA (Sadler and Verheem, 1996)

Category	Specific Methods Within Category
Literature search	State of knowledge - survey to identify linkages between policy actions and environmental impacts. "State of the Environment" reports and environmental policy plans will be useful documents to start with. Case comparison - of examples from other policy domains or jurisdictions. Analysis of similar actions in other countries can provide insight into the possible impacts of policy options.
Expert judgment	Delphi survey - iterative canvass of opinions and perspectives from recognized "experts" in pertinent fields. Workshops - structured meeting with a problem-solving focus, e.g., to develop alternatives or map possible impacts.
Analytical techniques	Scenario development - projections, based on reasoned assumptions, to outline and compare the means by which, or conditions under which, a proposed action may be implemented; e.g., "best" vs. "worst" case scenario of risks and impacts. Model mapping - identification of cause-effect networks to qualitatively illustrate linkages; e.g., policies will influence plans and programs, which will subsequently initiate projects. Checklists - those developed for project EIA have proven useful at the strategic level too, in original or modified form. Indicators - often, it will not be appropriate, possible or necessary to predict all environmental impacts of a proposed policy; instead, screening against relevant indicators may be sufficient for the purposes of a SEA. In many cases, indicators can be used to establish networks focusing on emissions and paths rather than actual effects on flora and fauna. Because indicators, by definition, need little aggregation, this may reduce the workload considerably. Note, however, the possible distortion that may occur in the simplification process implied by aggregating environmental variables into one single indicator.
Consultative tools	Interviews - with experts, opinion leaders, political representatives, etc. Selective consultation - with key interest groups and/or communities and sectors directly affected by a proposed policy, plan or program. Policy dialogue - round table or other multi-stakeholder process to clarify issues, determine consequences and identify options that meet the concerns and interests represented.

Table 7.9: Examples of Some Methods for Impact Analysis in SEA (Sadler and Verheem, 1996)

Extended use of identification methods - In most SEAs, relatively simple and straightforward methods will be sufficient. Examples include: literature survey, case comparison, expert judgment, scenario development and model mapping. This last technique is reported to have been effective for SEA. Often, it has proven possible to sufficiently quantify environmental indicators by filling in each parameter of an impact network, based on data from literature, indicative calculations or expert judgment.
Use of matrices - Grid diagrams can be used to cross-reference a list of (sub)actions to a list of environmental impact parameters. Most SEAs make use of matrices in some form. The UK Guide on SEA for Structure Plans recommends them as the main tool, including their use for consistency analysis to identify potential conflicts between objectives in different policy sectors.
Computer modeling - In some countries, computer models are used to calculate the impact of strategic options on environmental indicators. For example, these have been applied to habitat supply analysis in Canada and the US, and to simulate the impact of tax policy on (national) energy use, and vehicle mileage and use of public transport in the UK.
Geographic Information Systems - These are especially useful in land use planning, routing studies and assessing cumulative impacts of several projects in the same area. Also, they may be used to support impact analysis, e.g., calculation of land occupation or measuring environmental impacts as function of distance to pollution sources.
Cost effectiveness analysis - Used to select the option which achieves a target or goal at least cost (environmental or financial). This is a useful technique in cases where actions are clearly constrained by existing (environmental) targets or objectives, for example, ambient air and water quality standards, emission limits under or resource harvesting allocations.
Cost-benefit analysis (CBA) - Technique in which as many impacts as possible are expressed in a unified value; the benefit-cost ratio is a basis for choice between the options reviewed.
Multi-criteria analysis (MCA) - This is an advanced form of CBA in which separate scores on a number of key evaluation criteria are given, rather than using one, unified value to express the significance of all impacts (as is the case in CBA). Using mathematical operations, combinations of weights and criteria scores provide a ranking of options. The advantage of MCA over CBA is that it allows for the joint analysis of both environmental costs and financial costs, even when the environmental costs cannot be valued in monetary terms. MCA does not necessarily lead to one, unambiguous solution; it generally leaves some freedom to decision makers. A specific form of MCA is the "goals achievement matrix" which helps in identifying how an action may potentially contribute to a set of specified (environmental) objectives.
Aggregation methods - Used to translate "groups of indicators" into one, composite indicator. The aim is to make the total amount of environmental information more manageable. In this process, results are often weighed against each other and "trade-off" choices are made. In principle, these are political decisions, and therefore, care should be taken in using aggregation methods for SEA. Usually however, some aggregation is needed and possible without generating controversy. Some methods are: • index methods - aggregation by valuation and weighted summation; • monetary methods - all impacts are translated into one unit; as yet,they are insufficiently developed for use in EA; • source methods - aggregation on an impact basis, for example, energy sources according to their contribution to the emissions of CO_2, air pollution sources according to their contribution to acidification.
Life Cycle Analysis - A standardized method taking into account the total "life cycle" of goods or services from use of natural resources, via production of goods to the treatment of waste. A standardized method is "scored" on ten environmental issues: human toxicity, aquatic ecotoxicity, soil ecotoxicity, greenhouse effect, ozone production, acidification, eutrophication, smell, use of space and use of natural resources. Scores are weighed against existing environmental problems in the area.

Table 7.10: Application of Methods to Steps in SEA (Sadler and Verheem, 1996)

Step	Examples of Methods
Baseline Study:	• SOE reports and similar documents • environmental stock/setting • "points of reference"
Screening/Scoping:	• formal/informal checklists • survey, case comparison • effects networks • public or expert consultation
Defining Options:	(by reference to): • environmental policy, standards, strategies • previous commitment precedents • regional/local plans • public values and preferences
Impact Analysis:	• scenario development • risk assessment • environmental indicators and criteria • policy impact matrix • predictive and simulation models • GISs capacity/habitat analysis • benefit/cost analysis and other economic valuation techniques • multi-criteria analysis
Documentation for Decision Making:	• cross-impact matrices • consistency analysis • sensitivity analysis • decision "trees"

(1) checklists which show whether the PPP has an impact or not, sometimes with further details on, for instance, impact type (positive, negative) and magnitude;

(2) compatibility or consistency assessment, which tests whether different subcomponents of the PPP are internally consistent;

(3) scenario analysis (this can be useful in addressing cumulative effects);

(4) overlay maps or GIS showing, for instance, sites affected by the PPP as well as cumulative effects concerns;

(5) various index, indicator and/or weighting methods such as the Habitat Sustainability Index;

(6) computer models, for instance models which predict likely air pollution based on assumptions regarding vehicle type, number, occupancy rate, and fuel use; and

(7) expert opinion.

Table 7.11 summarizes, on a relative basis, the usage of several types of EIA methods for project-specific and cumulative effects, and for strategic-specific and cumulative effects. Table 7.12 delineates methods which could be used for air impacts prediction at both project and SEA levels. Finally, Table 7.13 illustrates types of EIA methods as shown in Table 5.2 herein in terms of whether they are focused on impacts to specific media or resources, or whether they can be used for an integrative consideration of impacts. Table 7.13 has applicability for project-level, cumulative, and strategic impact issues.

In summary, because of the relative newness of SEAs, pertinent methodologies are not as well-developed as for project-level EIA (Therivel, et al., 1992). As such methodologies are developed, they are expected to include more attention to economic valuation of impacts and to addressing uncertainty.

ADVANTAGES (USES) OF SEA

Three key uses of SEAs are as a means to strengthen project-level EIA; address cumulative and large scale effects; and incorporate sustainability considerations into the 'inner circles' of decision making (Sadler and Verheem, 1996). At a more specific level, several authors have articulated advantages associated with SEAs; for example, Wood and Dejeddour (1992) cited the following:

(1) encourages the consideration of environmental objectives during policy, plan and program-making activities within nonenvironmental organizations;

(2) facilitates consultations between authorities on, and enhances public involvement in, evaluation of environmental aspects of policy, plan and program formulation;

(3) may render some project EIAs redundant if direct, indirect, and cumulative effects have been assessed adequately;

(4) may leave examination of certain impacts to project EIA;

Table 7.11: Methods for Usage in Studies

Types of Methods See Chap. 5	Relative Usage			
	Project	Cumulative	Strategic	Cumulative
Analogs	H	M	L	L
Checklists	H	M	M	L
Decision-focused Checklists	M	L	L	L
ECBA*	L	O	O	O
Expert Opinion	H	M	M	L
Expert System	L	O	O	O
Indices or Indicators	M	L	M	L
Laboratory Testing	M	L	NA	NA
Landscape Evaluation	M	L	L	O
Literature Reviews	M	L	L	O
Mass Balances	H	L	L	O
Matrices	H	L	M	L
Monitoring (baseline)	L	O	O	O
Monitoring (field)	L	O	O	O
Networks	M	O	O	O
Overlay Mapping	M	L	L	L
Photographs/Photomontages	M	L	L	L
Qualitative Models	H	L	L	O
Quantitative Models	M	L	L	O
Risk Assessment	L	L	L	O
Scenario Building	L	O	L	O
Trend Extrapolation	L	L	L	O

H = relatively extensive (high) usage
M = relatively moderate (intermediate) usage
L = relatively low usage
O = limited usage, if at all
NA = not applicable
*ECBA = environmental cost benefit analysis

Table 7.12: Air Impacts Prediction at Project and Strategic Levels

Project:	Analogs
	ECBA (C)[a]
	Expert Opinion (C)
	Indices or Indicators (C)
	Laboratory Testing
	Landscape Evaluation (C)
	Literature Reviews
	Mass Balances (C)
	Monitoring (field)
	Overlay Mapping (C)
	Quantitative Modeling[b] (C)[c]
	Risk Assessment (C)
	Scenario Building (C)
	Trend Extrapolation (C)
Strategic:	Expert Opinion (C)
	Indices or Indicators (C)
	Literature Reviews
	Mass Balances (C)
	Matrices (C)
	Qualitative Modeling
	Quantitative Modeling (C)[d]
	Risk Assessment
	Scenario Building
	Trend Extrapolation

[a]C denotes can also be used for cumulative effects
[b]SCREEN2; ISC2 (single or multiple sources)
[c]ISC2 plus others
[d]Multisource regional model; atmospheric chemistry model

Table 7.13: Specific Versus Integrative Focus of Methods

Types of Methods in EIA	Focused on Impacts Related to Specific Media/Resources	Focused on Integrative Consideration of Impacts
Analogs	+	+
Checklists		+
Decision-focused Checklists		+
ECBA		+
Expert Opinion	+	+
Expert Systems	+	+
Indices or Indicators	+	
Laboratory Testing	+	
Landscape Evaluation	+	
Literature Reviews	+	+
Mass Balances	+	
Matrices		+
Monitoring (baseline)	+	
Monitoring (field)	+	
Networks		+
Overlay Mapping		+
Photographs/Photomontages	+	
Qualitative Models	+	
Quantitative Models	+	
Risk Assessment	+	+
Scenario Building	+	
Trend Extrapolation	+	

Note: Both columns could be related to CEA as appropriate.

(5) allows formulation of standard or generic mitigation measures for later projects;

(6) encourages consideration of alternatives often ignored or not feasible in project EIA;

(7) can help determine appropriate sites for projects subsequently subject to EIA;

(8) allows more effective analysis of cumulative effects of both large and small projects;

(9) encourages and facilitates the consideration of synergistic effects;

(10) allows more effective consideration of ancillary or secondary effects and activities;

(11) facilitates consideration of long range and delayed impacts; and

(12) allows analysis of the impacts of policies which may not be implemented through projects.

DIFFICULTIES (BARRIERS) RELATED TO SEA

While there are benefits related to planning and conducting SEAs, difficulties (barriers) and limitations have also been identified for such studies. For example, some of the difficulties encountered with SEAs include (Therivel, et al., 1992):

(1) the often nebulous nature of proposals at the level of policies and plans, and the tendency for decisions regarding PPPs to be made in an incremental and not clearly formulated fashion;

(2) the problems of system boundaries: the large number of potential decisions that flow from a higher-level decision, and the large number of potential developments over a physical or policy area, and thus the consequent analytical complexity required, including complexities related to cumulative effects considerations;

(3) lack of information about existing and projected future environmental conditions; lack of information about the nature, scale and location of future development proposals (reasonable foreseeable future actions); and thus the lack of precision with which these impacts can be predicted;

(4) the large number and variety of alternatives to be considered at the different stages of policy formulation;

(5) lack of shared information about the experience of EIA at the strategic level, and a dearth of cases in which it has been applied, especially to policies;

(6) the uncertainty over public involvement in the policy-making process; and

(7) the political nature of the decision-making process.

One argument which has been raised against a formal system of SEA at any government level is that for most PPPs there may not be a clear point in time when a decision is made (Therivel, et al., 1992). Another one is that environmental concerns, including cumulative effects, are addressed in general planning activities for geographical areas, regions, states or countries characterized by land use legislation and a strong land use planning system.

Some institutional barriers to the introduction and implementation of SEA requirements are identified in Table 7.14 (Sadler and Verheem, 1996). As shown, political will can be a barrier; it could also be seen as an advantage in situations where elected/appointed governmental officials serve as advocates for SEAs. The importance of political will was noted by Wood (1992) when he suggested that the major deterrent to SEA is "political," that is, the reluctance of politicians and senior bureaucrats in major governmental departments voluntarily to cede a role in decision making to environmental authorities by requesting SEAs of their activities. Political will can also be a deterrent to CEA; this topic is addressed in Chapter 14 herein.

To further illustrate the importance of political will, it should be noted that essentially all of the published literature on SEA is written by advocates and practitioners, hence the emphasis is often on the potential benefits of SEA. Further, statistics on the number of countries with SEA requirements, and specific relevant in-country laws and regulations, have been reported. An interesting question can thus be posed -- what do "user governmental levels" think of SEAs, and are they useful or even used in "real world situations?" McCarthy (1996) reported on a survey of the attitudes of local and state governmental agencies regarding the above question. A questionnaire survey was sent to 129 government agencies in South Australia in 1995, and 61 responses were received. Agencies contacted included 117 local councils and 12 state government departments. Key findings from the questionnaire results included the following (McCarthy, 1996):

(1) The principles of SEA were supported by the majority of agencies, although these principles were believed to be relevant only some of the time, depending on the environmental significance and the nature of the policy, plan, or program (in-house versus open process).

(2) Most agencies preferred a degree of formality in a SEA framework although almost half suggested that a combination of formal and informal elements was most appropriate.

(3) Most supported public involvement at this level of assessment, albeit only some of the time.

(4) The majority of agencies are practicing informal SEA some of the time, although this was a new practice for nearly a third of the respondents. For others, it was increasing in response to public demand.

(5) The majority of agencies lacked broad and explicit environmental goals as a framework for assessment, thus implying the need to improve the knowledge base as a precursor to SEA.

Survey participants also identified several constraints to SEA practice in South Australia. The identified constraints, shown in Table 7.15, are similar to constraints identified by several SEA practitioners

Table 7.14: Examples of Institutional Barriers to Introducing and Implementing SEA (Sadler and Verheem, 1996)

- Insufficient political will -- as indicated by low priority given to environmental concerns, public participation and integrated decision making;
- Lack of clear objectives -- e.g., absent or incomplete direction given to incorporating environmental goals into sectoral policies, plans and programs;
- Narrow definition of issues -- reflected in prevailing emphasis on economic growth and failure to consider the strategic environmental implications (including cumulative effects issues);
- Compartmentalized organizational structures -- typically, consideration of environmental matters is curtailed by the sectoral division of political powers and agency responsibilities;
- Absence of accountability -- often, economic agencies are not held responsible for the environmental implications of their actions;
- Lack of incentive -- policy makers and their senior advisors are seldom rewarded for anticipating and avoiding environmental problems; on the contrary, taking these into account usually generates additional pressures;
- Exigencies of decision making -- often political stresses dictate a fast response to events in which there is too little time to review and weigh economic consequences, let alone environmental ones; and
- Bureaucratic prerogatives -- environmental requirements encroach on "turf and territory" of other sectors, which is zealously guarded by officials, especially at the policy level.

Table 7.15: Constraints to SEA in South Australia (McCarthy, 1996)

Time and resource limitations
Lack of priority given to environmental considerations
Imprecise or ill-informed standards for compliance
The challenge of addressing issues which cross traditional discipline or departmental boundaries
Governmental agencies are as yet not obliged to embrace principles of environmentally sustainable development
Another level of bureaucracy in an already complex system
State control over local issues
Imposition from external authorities into internal processes
Some policies are too broad to assess and are continuously changing
Problems of external review by an independent agency

(McCarthy, 1996). Topics associated with improving SEA were identified as shown in Table 7.16 (McCarthy, 1996). While focused on South Australia, they have general applicability.

In summary, the oft-indicated barriers to the implementation of SEA include the following (Partidario, 1996):

(1) lack of knowledge and experience concerning which environmental factors to consider, what environmental impacts might arise (including cumulative effects) and how integrated policy-making can be achieved;

(2) institutional and organizational difficulties as reflected by the need for effective coordination amongst and within government departments;

(3) lack of resources (information, expertise, financial);

(4) lack of guidelines or mechanisms to ensure full implementation (including guidelines for CEA);

(5) insufficient political will and commitment to implement SEA;

(6) difficulty in stating clear policy proposals and in defining when and how SEA should be applied;

(7) methodologies not well developed;

(8) limited public involvement;

(9) lack of clear accountability in the application of the SEA process; and

(10) current project-specific EIA practices are not necessarily applicable to SEA and are inhibiting sound SEA approaches.

RESEARCH NEEDS

Because of the relative infancy of SEA, a number of research needs can be identified. One example is the need to quantify the costs and benefits of SEA; another is to identify and prepare appropriate professional-level training packages focused on SEA (Wood, 1992).

Some future directions and research needs related to the practice of SEA were recently addressed by Partidario and Therivel (1996) as follows:

(1) SEA is only really effective when it starts early and accompanies the entire PPP process, from its inception through the multiple stages of decision-making.

(2) SEAs and their included CEAs should be linked to sustainability, and should consider all the elements of sustainable development: economic, socio-cultural and biophysical. Trade-off analysis can be used to test various PPP approaches, and to ensure that SEA is not merely a pro forma exercise. Environmental considerations need to be fully considered in decision-making, on a par with financial and socio-economic considerations.

(3) Realistic SEA objectives and/or 'visions' must be established early on. It may be useful to establish targets or benchmarks

Table 7.16: Topics Related to Improving SEA in South Australia (McCarthy, 1996)

Need to reduce ministerial discretion
Need to maintain in-house responsibility of the process
Importance of using independent consultants for assessment
Importance of integrating assessment early into the process rather than retrospectively
Need to streamline the process to reduce delay
Belief that small counties and rural towns should be exempt from the process
Need for more resources/support
Need for more staff and cooperation between Chief Executive Officers and establishment of integrated teams
Need to improve lines of communication within government and with community
Need to update and simplify state environmental information

against which impacts can later be evaluated, but there may be political and economic difficulties in establishing these targets.

(4) SEAs should be based on a systematic methodology, possibly linking objectives, indicators, existing conditions analysis, impact predictions, mitigation and monitoring. SEAs should include a statement of the methods used in carrying out the analysis.

(5) The consideration of a range of alternatives is a crucial component in SEA, otherwise SEA risks becoming a post hoc exercise which merely justifies an agreed-upon PPP.

(6) SEA relies on the availability of suitable data; thus integrated databases need to be developed.

(7) Simple impact (direct, indirect, and cumulative) prediction and evaluation techniques are often as useful as, and considerably less resource intensive than, more complex techniques. New techniques specific to SEA need to be developed, including simple methods for dealing with uncertainty.

(8) The interest groups involved in SEA -- including the public -- need more training in SEA techniques, and need to communicate more with one another. Consultation with relevant experts and the public is crucial to SEA. Transparency and legitimacy needs to be encouraged.

CONCLUSIONS

Strategic environmental assessments are receiving greater attention in the world-wide practice of environmental impact assessment. The broader range of considerations within SEAs, including cumulative effects, can represent both opportunities and concerns related to planning considerations for enhancing environmental quality and/or minimizing environmental deterioration. Opportunities are reflected by a more logical basis for choosing the geographical area for study within the SEA and related CEA. Further, siting-related decisions can be based on cumulative effects and sustainable development considerations, and on protecting the most valuable/sensitive natural resources. Planning can also be done from an holistic perspective and not from a more limited institutional focus. However, there are numerous concerns related to planning and implementing SEA studies. Pragmatically, such concerns include:

(1) lack of PPP specificity may limit specific considerations, thus an "impact footprint" approach is needed;

(2) nonavailability of regional/national plans for reference; or the availability of limited plans which are out-of-date;

(3) the larger scale of SEAs multiplies the effort needed for data gathering on other projects, environmental resources, laws, etc.;

(4) the environmental carrying capacity needs to be considered in relation to cumulative effects, and there may be a lack of information on this capacity;

(5) the uncertainties may be greater than for project-level EIA;

(6) there is typically a greater need to address cumulative effects and transboundary impacts; and

(7) the possible confusion as to whether certain topics should be addressed in a SEA or a subsequent project-level EIA, or both.

Finally, due to the relative newness of SEAs, there is a great need for case studies from which lessons learned can be articulated. This information could be used in developing training programs related to SEA. Such "lessons learned" would be helpful to substantive area professionals who may be poorly trained to think holistically and on broader spatial and temporal scales.

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CHAPTER 8

CEA CASE STUDIES

Because the practice of CEA is relatively new, value can be gained from the review of case studies. Accordingly, Table 8.1 identifies over 30 examples from a variety of types of projects, plans, or programs which include CEA. A systematic review of the CEAs on 10 Canadian case studies has recently been conducted. The types of projects, locations, and major VECs are shown in Table 8.2 (Cumulative Effects Assessment Working Group, 1997). Based upon this review, the following lessons were derived (Cumulative Effects Assessment Working Group, 1997):

(1) Assessment of cumulative effects on some components is relatively straight forward if quantitative tools and thresholds are available (e.g., for regulated constituents of air and water).

(2) Qualitative conclusions and ranking systems are useful to communicate results if supported by defensible quantitative analysis.

(3) Incremental changes caused by the project under review should be measured relative to an established baseline condition.

(4) Assess effects during "snapshot" points in time.

(5) Perform an assessment from the point of view of effects on VECs as opposed to interactions between actions.

(6) Interactions do not need to be assessed individually; characterize the entire surrounding environment as it "appears" to each VEC.

(7) Other past and existing actions become part of the background environment for a VEC.

(8) Lack of information regarding other actions may limit the assessment of their contribution to effects.

(9) As many disturbances are temporary, effects often recover within an acceptable period of time.,

(10) Induced activities (e.g., road proliferation) may be an important cause of effects.

REVIEW OF EISs -- SOME BRIEF CASE STUDIES

Several EISs have been selected and systematically reviewed relative to how cumulative impacts were addressed (Kamath, 1993). Two examples will be briefly highlighted -- the Elk Creek Lake project of the U.S. Army Corps of Engineers in the Rogue River Basin in Oregon (U.S. Army Corps of Engineers, 1991), and the Monticello B-2 area surface lignite mine proposed by the Texas Utilities Mining Company (TUMCO) in Titus County, Texas (U.S. Environmental Protection Agency, 1990).

Table 8.1: Examples of Case Studies Involving CEA

Case Study	Reference
Uranium mines development in northern Saskatchewan, Canada	Damman, Cressman, and Sadar (1995); Dupuis and Hegmann (1997); and Zukowsky and Gates (1994)
Incremental land developments in the greater Toronto portion of the Oak Ridges Moarine land form in Ontario, Canada	Damman, Cressman, and Sadar (1995)
Military air defense training areas in New Brunswick, Canada	Barnes and Westworth (1994)
Expansion of an existing gas gathering system associated with gas development activities in the Great Sand Hills area of Saskatchewan, Canada	Bennett (1994)
Expansion of ski development and construction of two golf courses in the Eastern Slopes area of Alberta, Canada	Bennett (1994)
Natural gas development in northeast British Columbia, Canada	Antoniuk (1994)
Regional planning in the Greater Vancouver region of British Columbia, Canada	Colnett (1991)
Regional studies of water quality and fisheries impacts of small hydropower projects in the San Joaquin and Owens River Basins in California; and the Ohio River Basin in Ohio, Pennsylvania, and West Virginia; in the USA	Cada and Hunsacker (1990)
Open cut mining of black coal in Australia	Court, Wright, and Guthrie (1994)
Coastal zone regional development in Australia	Court, Wright, and Guthrie (1994)
Bleached kraft paper mill in Alberta, Canada	Dupuis and Hegmann (1997)
Coal mine in Alberta, Canada	Dupuis and Hegmann (1997)
Oil pipeline in Alberta, Canada	Dupuis and Hegmann (1997)
Spent nuclear fuel management program at the Savannah River Site in South Carolina in the USA	U.S. Department of Energy (1995a)
Nationwide study of managing radioactive and hazardous wastes from nuclear defense activities in the USA	U.S. Department of Energy (1995b)

Table 8.1 (continued):

Oil and gas exploration, development, and production activities associated with four outer continental shelf regions (Atlantic, Gulf of Mexico, Pacific, and Alaska) in the USA	Van Horn, Melancon, and Sun (1988)
Lease sales of recoverable oil and gas resources in two areas of the outer continental shelf in the Gulf of Mexico region in the USA	Minerals Management Service (1995)
Hazardous waste facility in Ontario, Canada	Lawrence (1994)
Cumulative social impacts from resource development activities in several aboriginal communities in western Australia	Ross (1990)
Expansion of existing oil sands mining, extraction, and upgrading facility in northeastern Alberta, Canada	Smith (1994)
Oil and gas leasing and development in New Mexico in the USA	Canter and Kamath (1995)
Housing/urban development project in McKinney, Texas in the USA	Canter and Kamath (1995)
Installation and operation of Doppler weather radar facilities at airports in the USA	Canter and Kamath (1995)
Surface water reservoir project in the Rogue River Basin in Oregon in the USA	Canter and Kamath (1995)
Surface lignite mine in Texas in the USA	Canter and Kamath (1995)
Multiple permit applications for surface and underground coal mines in Tennessee in the USA	Myslicki (1993)
Vegetation management in designated national forests in the Pacific Northwest region of the USA	Myslicki (1993)
Boll weevil cooperative control program in the USA	Myslicki (1993)
CEA of historical development and resource removal projects in the Fraser River Estuary area in western Canada	Sonntag, et al. (1987)
Forest exploitation and forestry management in New Brunswick Province in Canada	Sonntag, et al. (1987)
CEA of development projects on the harvesting of renewable resources in northern Canada	Sonntag, et al. (1987)
Comparative review of 10 case studies in Canada (industrial plant, three mines, heavy oil extraction, residential development, hydroelectric dam, highway, highway and railway, and recreational trail)	Cumulative Effects Assessment Working Group (1997)

Table 8.2: Case Studies Subjected to Systematic Review (after Cumulative Effects Assessment Working Group, 1997)

Project	Type of Project	Major VECs	Location
Alberta-Pacific Pulp Mill	Industrial process	Water	AB
Northern Saskatchewan Uranium Mines	Mines (underground)	All	SA
Cold Lake Oil Sands Project	In-situ heavy oil	Water	AB
Cheviot Coal Mine	Mine (open-pit coal)	Wildlife, water	AB
Huckleberry Copper Mine	Mine (open-pit base metal)	Water, fish	BC
Eagle Terrace Sub-division	Residential development	Wildlife	AB
Keenleyside Power Project	Hydro-electric dam	Water, fish	BC
Trans-Canada Highway Twinning Phase IIIA	Highway	Wildlife	AB
Transportation Corridors (Glacier and Banff National Parks)	Highway, Railway	Visual	BC
La Mauricie National Park Hiking Trail	Recreational trail	Wildlife	QU

AB = Alberta
SA = Saskatchewan
BC = British Columbia
QU = Quebec

Elk Creek Lake, Rogue River Basin, Oregon

The Elk Creek Lake project was authorized by the Flood Control Act of 1962 as one of the three multiple-purpose dams in the Rogue River Basin. The three dams, namely, the Lost Creek Lake Dam, the Applegate Lake Dam and the Elk Creek Lake Dam were designed to operate as a system to reduce flooding in the Rogue River Basin, and also to accomplish the additional purposes of water supply, irrigation, fish and wildlife enhancement, hydropower, and recreation (see Figure 8.1). While the construction of dams at Lost Creek and Applegate were completed, construction at the Elk Creek Lake was stopped as a suit was filed by the Oregon Natural Resources Council in the U.S. District Court based on the allegation that the U.S. Army Corps of Engineers had not fully complied with the provisions of the NEPA before beginning construction of the Elk Creek Dam. The Federal Ninth Circuit Court of Appeals found that the 1980 EIS Supplement was deficient in several aspects, including inadequate consideration of the cumulative impacts of the three dams (U.S. Army Corps of Engineers, 1991). The 1991 EIS Supplement mainly focused on the shortcomings of the earlier one and took into account the concerns identified by the Oregon Natural Resources Council and comments received in response to the scoping notice (U.S. Army Corps of Engineers, 1991). This summary targets the cumulative impacts addressed in the 1991 EIS Supplement.

The 1991 EIS Supplement evaluated two levels of alternatives for the Elk Creek Lake project. In the first level, the alternatives were the proposed action (completing the project), and no action, which means that the project would not be constructed. In the second level, the alternatives addressed the operation of the project (if it were to be completed) and the disposal of the existing structure (if the no action alternative were selected). Details on the environmental effects of the alternatives are in the EIS Supplement (U.S. Army Corps of Engineers, 1991). The following subsections summarize the short-term, long-term and cumulative impacts due to the three dams on the physical environment, biological environment, and regional economics in the study area (U.S. Army Corps of Engineers, 1991).

(a) Physical Environment

The topography of the Elk Creek basin is characterized by mountainous terrain with long, rounded ridgetops, steep slopes, and moderate to high stream gradients. The geology of Elk Creek watershed is composed of 60% rhyolite flowrock and pyroclastics.

The soils in the watershed have been mapped by the Corps of Engineers, Bureau of Land Management (BLM), U.S. Forest Service (USFS), and the Soil Conservation Service (SCS). There is controversy due to apparent difference between the SCS soil survey and the 1980 Elk Creek Lake EIS Supplement No. 1, with respect to soil-turbidity relationships. The discrepancy found is that the SCS and Corps soil maps depict different soil units and this raises the question of whether or not changes in the soil and geologic data have a significant effect on the predictions made by the reservoir water quality model, as this model uses statistical relationships to derive turbidity values and does not use soil or geology data for input. With respect to the reservoir area, long-term turbidity producing soils were identified by intensive empirical testing.

The Elk Creek project site has been subjected to minor damages caused by earthquakes; however, faults mapped in the vicinity of the project are inactive. The loss of rock resources for construction of Elk Creek Dam and the relocated County Road 941, and gravel deposits which would be inundated by the flood pool, comprise the greatest effects of dam

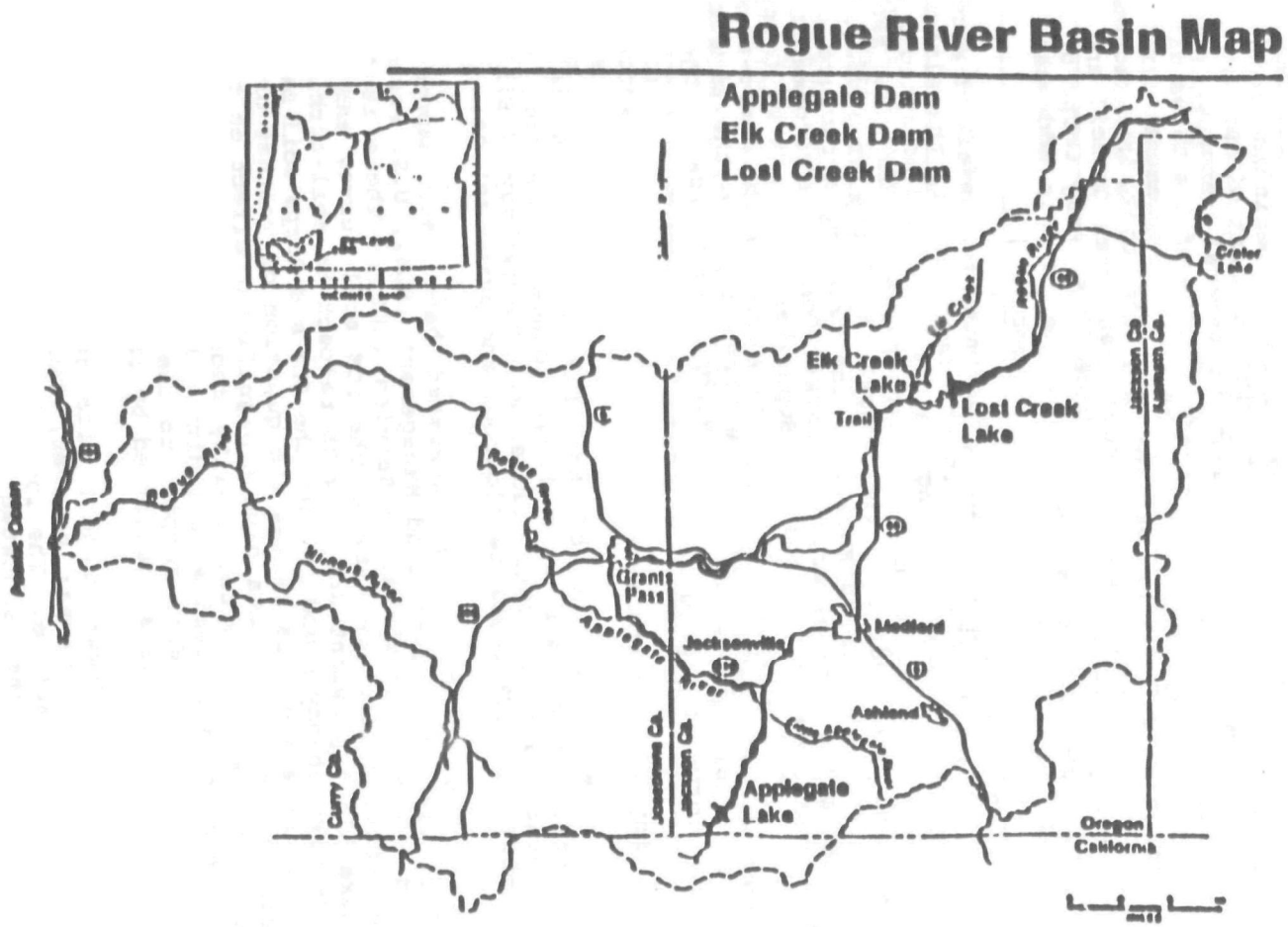

Figure 8.1: Rogue River Basin Map (U.S. Army Corps of Engineers, 1991)

construction on the geologic resources of the Elk Creek watershed. Also affected will be the gravel recruitment process whereby sediments are continuously being transferred downslope from the upper reaches of the watershed to the lower reaches. This is a very long-term process in streams with gravel beds such as Elk Creek.

The combined geomorphological effects of Elk Creek, Lost Creek, and Applegate Dams on the Rogue River are insignificant due to the stable characteristics of the gravel bed streams. Erosion within the reservoir area is dependent upon soil type, vegetative cover, exposure to wind and wave action, and slope angles. Seismicity will be unaffected by Elk Creek Dam and likewise, no significant slope stability effects are expected as a result of dam construction.

The climate of the Rogue River Basin is characterized by mild, wet winters and warm, dry summers. The streamflow regime of the Rogue River and its tributaries is similar to the precipitation pattern. Low flows occur from July through September or October, and moderate to high flows occur during the remainder of the year. The results of evaluation of the different alternatives showed that for two periods, namely, the reservoir filling (February through April) and the reservoir drawdown periods (July through October), the conservation storage and release seasons have the greatest effects on downstream flows.

The two major factors considered in water quality are water temperature and turbidity. The construction of the dam to impound water not only changes the flow regime of the river, but also creates a reservoir that acts as a thermal regulator to the aquatic system. Analysis of the cumulative impacts of operating Elk Creek Dam on the water temperatures in the Rogue River demonstrated that the effects would be minimal; therefore, no adverse effects on water temperature from the addition of Elk Creek Lake to the existing system are anticipated. Rogue River Basin waters exhibit highly turbid characteristics during, and immediately following, high runoff events in the watershed. It was determined that turbidity levels at the confluence of the Elk Creek with the Rogue River would show very little effects due to releases from Elk Creek Dam, and without the dam, the water quality in the Rogue River would continue to be the same due to the already existing dams.

(b) Biological Environment

The Rogue River has historically supported in-river sport fisheries for spring Chinook and fall Chinook salmon, coho salmon, and summer and winter steelhead. Salmon species have also contributed to a large commercial and sport troll fishery in the nearby Pacific Ocean. With construction of the Lost Creek Dam, blockage to the passage of anadromous fish in the Rogue River occurred and their production from upstream no longer occurs. Augmented summer flows, lower summer temperatures, and higher winter temperatures in the Applegate River resulting from the operation of the Applegate Lake project primarily affect fall Chinook salmon and winter steelhead.

With the Elk Creek project the potential effects of changes in flows, water temperatures, and turbidity on fish production and fishing activity were evaluated for different operating alternatives, and the survival of Chinook and steelhead eggs during flood control operations has been demonstrated.

A two step process was used to determine wildlife habitat values, project effects, and appropriate mitigation measures. The U.S. Fish and Wildlife Service's (USFWS) Habitat Evaluation Procedures (HEP) were used to assess habitat impacts associated with the three Rogue River Basin

projects. Cumulatively, the completion of Elk Creek Lake in combination with the two existing Rogue Basin projects would result in direct habitat degradation and/or loss on 6,770 acres of a land base estimated at 18,024 acres (see Table 8.3) (U.S. Army Corps of Engineers, 1991).

The project would affect bald eagles in the short-run through a reduction in available prey. Long-term impacts were estimated to have a positive effect on bald eagles due to development of a fisheries resource in the Elk Creek basin coupled with management strategies. Again, the project would have no effect on peregrines beyond a possible minor, short-term reduction in prey availability. Therefore, given the retention of trees in the Elk Creek Lake, adjacent mature forested habitat, and establishment of a warm water fishery, bald eagles are expected to establish a territory at Elk Creek Lake some 5-10 years post inundation; therefore, the cumulative impacts on bald eagles arising from construction and operation of the overall Rogue River Basin projects will be positive.

(c) Recreation and Economics

Changes in the river flow caused by operation of Elk Creek Lake, in conjunction with Lost Creek and Applegate Lakes, may have some effects on recreational usage of the Rogue River downstream. The degree and type of effects would vary depending on whether the lake is operated at full storage capacity, at a minimum flood control pool, or with no conservation pool.

The total cost of construction for Elk Creek dam and reservoir is presently estimated to be $183,000,000. The positive cumulative impacts associated with construction employment and income are judged to be significant. Over 10,000 acres of land formerly in private ownership has been converted to project lands and removed from the county tax rolls. A natural increase in tourism has occurred with the projects. Economic impacts with respect to operation and maintenance requirements of Elk Creek are expected to be minimal.

(d) Synopsis of Cumulative Impacts

There were four concerns associated with the 1980 EIS Supplement and one of them was that the cumulative impacts of Elk Creek Lake in conjunction with the Lost Creek and Applegate Lakes were not adequately addressed. The 1991 EIS Supplement addressed and evaluated the cumulative impacts of the three Rogue Basin projects using mathematical models and checklists. The assessment used both qualitative and quantitative information. Wildlife impact evaluation was accomplished using HEP. Economic effects due to the three projects have also been evaluated. In general, the 1991 EIS Supplement provided a systematic and quantitative basis for addressing cumulative impacts.

Monticello B-2 Area Surface Lignite Mine--Titus County, Texas

The Monticello B-2 Surface Lignite Mine proposed by Texas Utilities Mining Company (TUMCO) is a new source for discharging pollutants and the new source National Discharge Elimination System (NPDES) permit is considered to be a major federal action significantly affecting the quality of human environment. Therefore, this draft EIS was prepared to assess the potential environmental consequences of EPA's New Source NPDES permit action (U.S. Environmental Protection Agency, 1990).

The surface lignite mine is located near Mount Pleasant in Titus County, Texas; the study area encompasses approximately 13,650 acres with lignite reserves estimated at about 80 million tons (see Figure 8.2). The

Table 8.3: Cumulative Wildlife Habitat Impacts for Elk Creek, Lost Creek, and Applegate Projects, Rogue River Basin Projects, Oregon (U.S. Army Corps of Engineers, 1991)

	Elk Creek	Lost Creek	Applegate	Summary
Project Acreage	3521	8384	6119	18024
Impacted Acreage	1459	4052	1259	6770
Target Species	Net Loss in AAHU's			
Beechey Ground Squirrel	-700	-283	-22	-1005
Western Bluebird	-1002	-2212	-629	-3743
Mallard	658	1156	302	2116
American Kestrel	-905	-1938	-577	-3420
Pileated Woodpecker	-365	-1729	-553	-2647
Black-tailed Deer	-711	-2083	-643	-3437
Roosevelt Elk	-646	-1208	0	-1854
Western Terrestrial Garter Snake	-213	-1540	-551	-2304

AAHU = annualized average habitat units

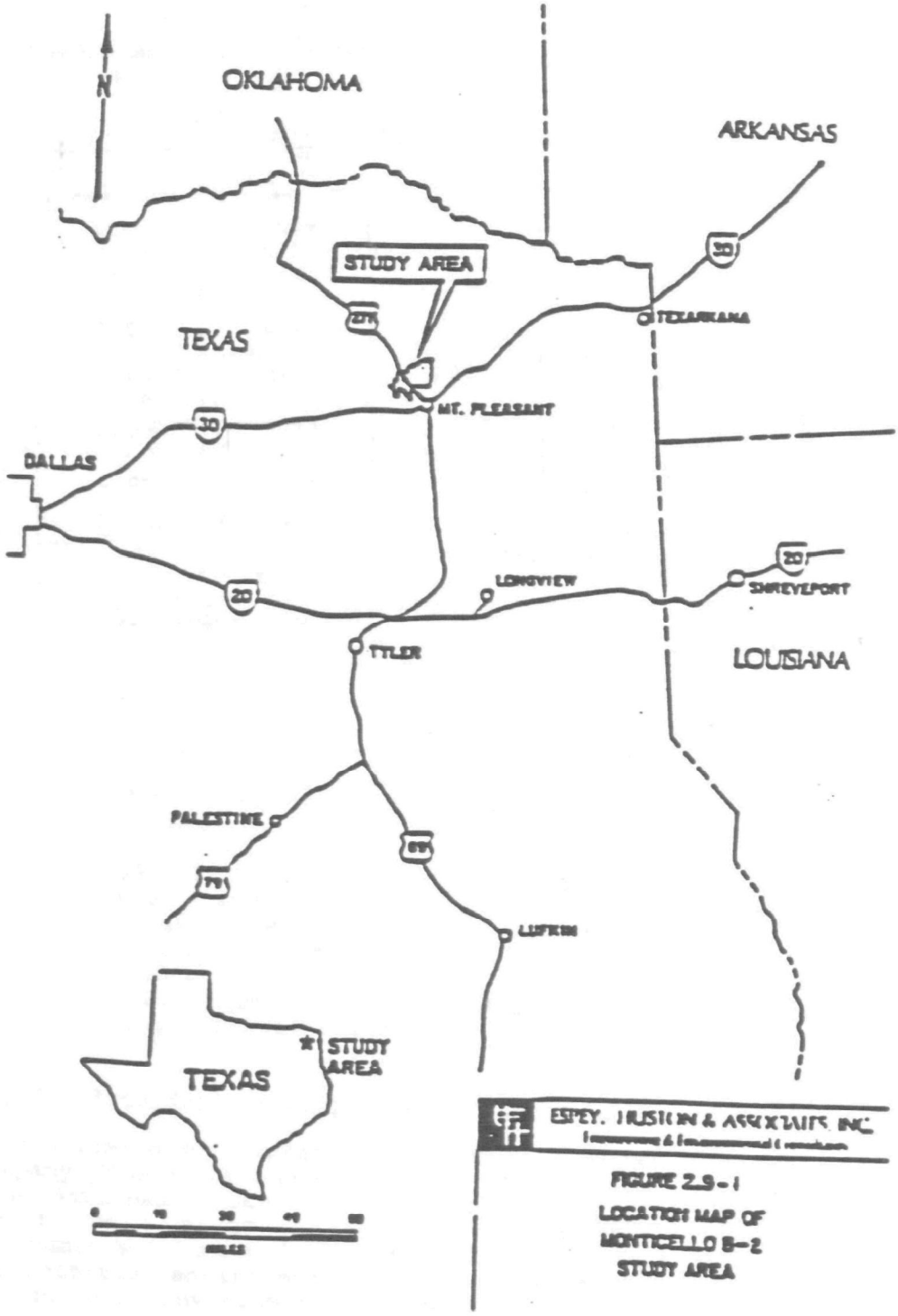

Figure 8.2: Location Map of Monticello B-2 Study Area (U.S. Environmental Protection Agency, 1990)

mine will be owned and operated by TUMCO, which is a wholly owned subsidiary of Texas Utilities Company. The recovered lignite is for use by Texas Utilities Electric Company (T.U. Electric) at the Monticello Steam Electric Station (MOSES) in Titus County, in the vicinity of Mount Pleasant. The mining operation is planned to be by surface techniques utilizing draglines as the primary overburden-removal equipment. The lignite will be hauled from the immediate mining area to a train loading station, and from that point transported by train to the Monticello power station utilizing the T.U. Electric railroad system. The project will require the construction of certain site facilities such as haul roads, surface-water control structures, service roads, and transmission lines in support of the mining operation.

The B-2 mining area will supplement the production of lignite along with other mining areas, in order to maintain the required annual production level to sustain the generating units of the T.U. Electric operated MOSES, and is required to be in operation in 1992. The quantity of reserves available currently from the Winfield and Thermo sites is inadequate to fuel MOSES for the minimum anticipated facility life of 35 years, and the loss of generating capability at MOSES prior to the end of the useful life of the generating units would result in an economic hardship to T.U. Electric. Moreover, the conversion of the Monticello units to use alternate fuels would significantly increase the capital and operating costs of the plant, and hence result in the inability to supply low-cost electricity to the consumer.

The environmental consequences due to the Monticello B-2 lignite mine project on several environmental categories are delineated in the EIS (U.S. Environmental Protection Agency, 1990). TUMCO's total mining operations (existing and proposed) directly affects approximately 30,000 acres. This mining will exhibit a number of short-term and long-term, adverse and beneficial cumulative impacts. Table 8.4 summarizes the cumulative impacts on different environmental categories due to the mining activities by TUMCO (U.S. Environmental Protection Agency, 1990).

This EIS used a qualitative checklist to address and assess cumulative impacts. Appropriate potential impacts were addressed, but quantification of impacts would definitely help in decision making. In addition, cumulative impacts in terms of other existing mines in the area, when coupled with the potential impacts of the Monticello B-2 mine, were not adequately addressed.

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Table 8.4: Cumulative Impacts Summary Table for Mining Project (U.S. Environmental Protection Agency, 1990)

Environmental Category	Cumulative Impacts
Topography	Regulations require that post-mined lands be returned to their approximate original contour, no irretrievable commitment and no long term cumulative impacts are anticipated.
Geology	Mining mixes sand and gravel deposits in the overburden with silts and clays reducing its commercial value, constituting an unavoidable, long term, adverse impact and irretrievable commitment of resources.
Soils	Replacement by reconstructed soils following mining will result in changes to the physical and chemical properties of the surface soils. Adverse impacts include short term increases in erosion rates until vegetation can be re-established.
Ground Water	Flow conditions and the localized area projected to experience water level declines from dewatering and/or depressurization activities.
Surface Water	Small incremental impacts on water quality and quantity resulting from the individual mining projects and due to geographic separation between the projects, no adverse cumulative impacts are anticipated.
Vegetation	Primary cumulative adverse impact results from the loss of habitat and naturally occurring drainage features, which require extended periods to fully re-establish following reclamation.
Wildlife Resources	Primary cumulative adverse impact results from the loss of wildlife habitat. This loss is considered a major long-term adverse impact.
Aquatic Resources	Losses include decreases in some fish and larval insect species. This minor net loss in the aquatic energy base is expected to be a short-term impact.

Table 8.4: (continued)

Air Quality	Adverse cumulative impacts associated with fugitive dust from surface mines, lignite piles, and haul roads, and equipment exhausts are not expected due to the large character of such emissions. These large particles tend to settle out of the atmosphere within a short distance of their emission point.
Sound Quality	Due to attenuation of sound levels with distance, no adverse cumulative impacts are anticipated resulting from noise.
Cultural Resources	A total of 354 recorded cultural resources sites will be affected and with survey, testing and/or mitigation of significant sites, recovery of cultural resources data will lessen the adverse impacts.
Post-Mining Land Use	Even though post-mining land use is consistent with existing land use, the cumulative effect of mining/reclamation over the life of TUMCO's mining is a long-term increase in improved over unimproved/natural conditions. Temporary adverse impacts on land use and productivity will occur until reclamation takes place.
Socioeconomics	The TUMCO mining operations in the area cumulatively provide an important economic factor in a region that experiences a higher unemployment rate than the state as a whole. But, cumulative impacts are not expected to be greatly exceed existing employment levels because of local transfers of personnel.
Environmental Category	Demand for public services should not exceed existing levels.
Public Health	Due to limited impacts of the individual minimal activities on public health, no cumulative impacts with other TUMCO mining projects are anticipated.

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CHAPTER 9

AIR QUALITY CUMULATIVE EFFECTS ASSESSMENT -- A PRACTICAL EXAMPLE*

Multiple methods and techniques have been developed to assist environmental planners in assessing the effects of human activities on their surroundings. A particular issue of current concern is the evaluation of the cumulative effects of proposed actions in relation to nearby past and future actions. However, cumulative effects assessment (CEA) has been criticized as being too comprehensive and complex to be incorporated into the project-specific impact assessment process (Dixon and Montz, 1995). For example, several applicable theories and methods for conducting CEAs can be found along with ideal attributes that should be included. Seminars, conferences, and even court cases, have contributed to what is considered to be necessary for adequate CEA. Often, however, practitioners tasked with conducting CEAs are left with multiple theories, methods, ideal components, and suggestions that, while valuable, do not demonstrate the rudimentary mechanics of how to get the job done.

This chapter presents a practical application of a method to identify and offer resolution for the difficulties associated with data collection, effects prediction, and analysis. The basis is an 8-step method for cumulative air quality effects assessment (CAQEA) proposed by Rumrill and Canter (1998b) (see Table 9.1). These steps, which are described in Chapter 2 herein, incorporate the data collection and evaluation tasks necessary to generate quantitative air quality cumulative effects (CEs) information. By applying the steps to a U.S. Air Force base (AFB), a federal facility subject to the requirements of the National Environmental Policy Act (NEPA), and the surrounding area, quantitative and qualitative data can be developed in a format applicable to significance determination of the effects in context with the direct air quality effects of an individual major action. The intent is for CEs to be compiled as an independent document and incorporated by reference into individual project impact analyses.

The AFB selected represents a typical facility. It is located in the southwestern section of the United States and consists of a single mission wing with typical support structure. It has an active flight line and is not currently scheduled for base closure. The future activities scheduled are typical of AFBs where the intent is to maintain and improve the current mission capabilities but not take on new mission responsibilities. There are no currently existing mission critical deficiencies. The adjacent city is small (approximately 100,000 residents) but is experiencing gradual linear growth (as projected in the city growth trends report) within a well established industrial and commercial economy. Conducting a study of an AFB located near a small population center with relatively few concerns about ambient air pollution allows for the exploration of various data limitation scenarios and the development of evaluation options to apply to each.

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*This chapter is co-authored by J.N. Rumrill (Graduate Student) and L.W. Canter.

Table 9.1: Steps for Cumulative Air Quality Effects Assessment (CAQEA) (after Rumrill and Canter, 1998b)

1. Select definition of CE to be applied in the analysis.
2. Determine spatial and temporal boundaries.
3. Determine past, present, and reasonably foreseeable future actions to be included in the analysis.
4. Determine baseline ambient air pollutant concentrations and obtain applicable standards or regulations.
5. Develop quantitative and qualitative emission data estimates for the actions determined in Step 3.
6. Determine quantitative and qualitative changes to baseline air quality (determined in Step 4) resulting from evaluated actions.
7. Evaluate the CE significance in context with the air quality impacts of the action originally generating the NEPA requirement and incorporate that significance into the assessment.
8. Include mitigation opportunities for CEs when discussing specific action impact mitigation.

STEP 1 -- DEFINITION SELECTION

Step 1 involves the selection of a definition for cumulative effects (impacts) to be used throughout the study. The intent is to standardize the definition employed by a federal agency and thus minimize the potential for variation between assessors as to their perceptions of the meaning of CEs. The Council on Environmental Quality (CEQ) definition was selected; it states that cumulative impacts (or CEs) result from

> "the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7 as found in Council on Environmental Quality, 1996).

The same definition should be applied when considering CEs on other environmental resources as well as in each individual project environmental impact study.

STEP 2 -- BOUNDARY DETERMINATIONS

Step 2 relates to the determination of spatial and temporal boundaries for the analysis. Based on discussions and recommendations in various literature sources, the time frame considered reasonable for air quality CEA for application to an AFB was 10 years; two years of the "past" and eight years of the "future." This determination was based on the availability of past and current air quality data and the relative degree of certainty that could be applied to AFB and local plans for future activity.

Regarding spatial boundaries, consideration was given to both the physical airshed and existing political boundaries. Political boundaries can influence the number and types of future actions, significance determinations, and mitigation decisions. Initially, the political boundaries considered were: (1) the AFB property boundaries; (2) the city limits; and (3) the county in which the AFB and city are located. The airshed boundaries were determined to be linked to the prevailing wind speed and direction. When applying the quantification measures suggested in Rumrill and Canter (1998a), spatial dimensions can be determined by considering the distance a theoretical parcel of air would travel given the prevailing wind speed and direction over a time period considered to be reasonable for uniform mixing assumptions. For this example, multiplying the annual average wind speed of 5.66m/sec and a typical mixing time of 1 hour resulted in a downwind distance roughly equivalent (approximately 12% larger) to the physical length of the developed land area of the city. Also, while valuable information was obtained from county level sources, insufficient data was available to forecast future development for the entire county. Therefore, the analysis was limited to the effects of the AFB in context with the surrounding city. The total geographical area was approximately 268 sq. km (see Figure 9.1).

STEP 3 -- ACTIVITIES TO EVALUATE

Step 3 requires the identification of past, present, and reasonably foreseeable future actions (RFFAs). The 8-Step Conservative Determination Method for RFFAs proposed by Rumrill and Canter (1997) (see Figure 9.2) was applied to the determination of RFFAs. The Method was based upon an analysis of the principles included in over 40 U.S. court cases related to

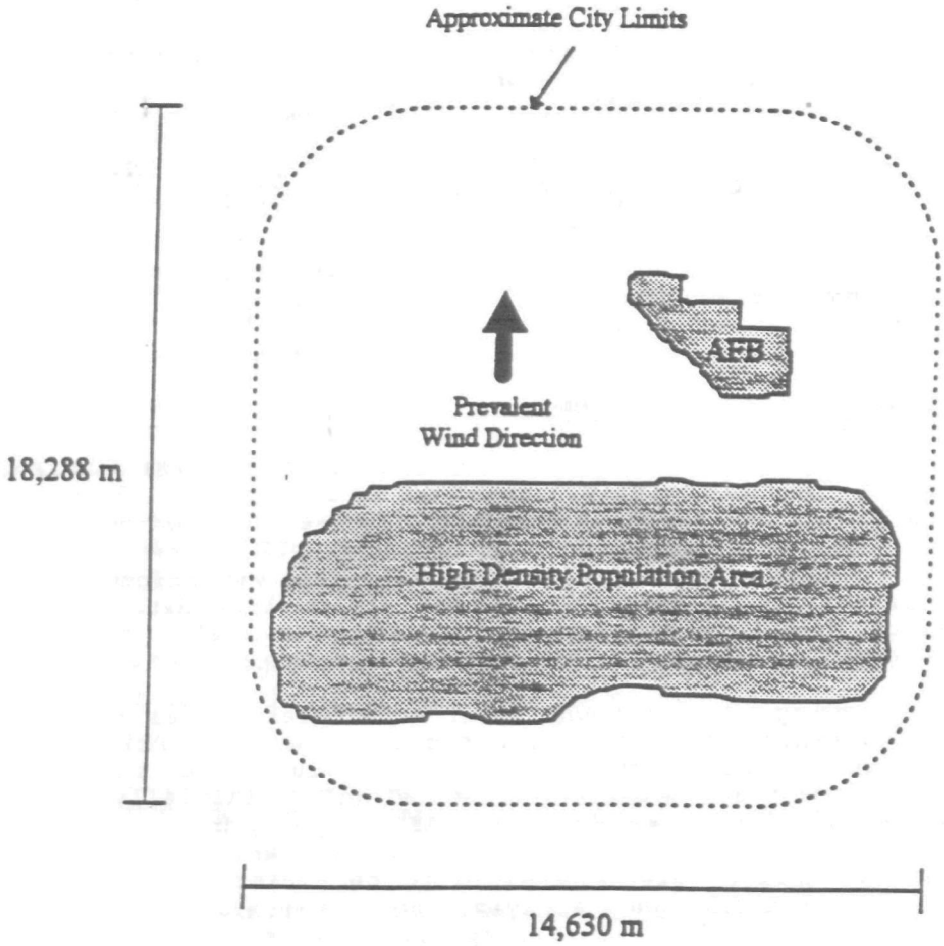

Figure 9.1: Approximate Geographical Area for Analysis

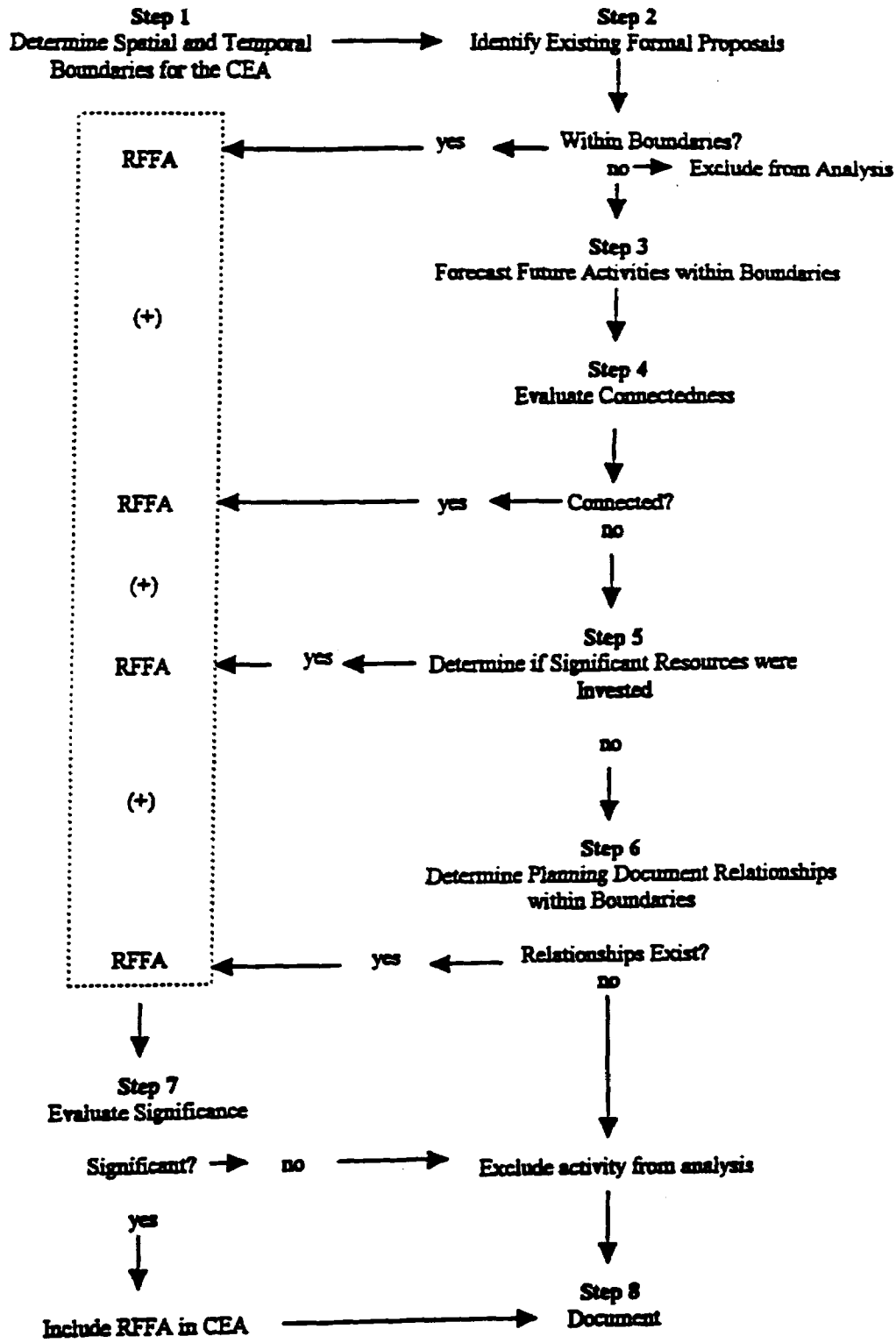

Figure 9.2: 8-Step RFFA Determination Method (Rumrill and Canter, 1997)

RFFAs. Step 1 of the RFFA method, the determination of boundaries, overlaps with Step 2 of the overall method utilized herein. The initial boundary determinations were made prior to addressing activities (past, present, and RFFAs), however, adjustments were made due to identified data gaps resulting from information gained in this portion of the analysis.

Past and present activities were considered to be incorporated into the existing air quality determination (Step 4 in Table 9.1). Activities addressed included: major, permitted sources; natural gas combustion from non-permitted (including household) furnaces and boilers; road vehicle use; non-road vehicle use (e.g., aircraft, lawnmowers, etc.); and fugitive emission from solvents, adhesives, paint, waxes, etc.

The RFFA determination steps outline an evaluation process for rational inclusion and exclusion decisions regarding future activities. It is not meant to restrict the assessor from gathering data relative to a specific step prior to the completion of all previous steps. In this case, the requirement for identifying formal proposals within the subject agency (Step 2 in Figure 9.2) was satisfied by review of the capital improvements program section of the AFB comprehensive development plan (CDP). This AFB plan provided information on over 200 formal and informal development activities from 1996 to 2004. Informal projects were identified with the phrase "project not scoped." The proposals included in this plan were limited to those with an estimated construction of $75,000 or greater. Smaller projects activities are typically not projected beyond one year. However, several of the projects that are included in the CDP would qualify for categorical exclusion under the environmental impact assessment (EIA) process. Due to the apparent comprehensive effort by others in including future actions in the capital improvements program, no further efforts were made herein to identify AFB proposals.

The city planning office was contacted to determine what, if any, future actions were planned. It was found that the city did not have a comprehensive plan, however, other planning documents were available. The city had a current version of a transportation development plan which included over 100 transportation-related development projects over a 20 year period from 1995 to 2015. Additionally, the city planning office was able to provide a growth trends study showing the historical population and housing trends from 1985 to 1995. These trends were used to forecast future population estimates and housing requirements. Table 9.2 presents the method used to project future populations and housing requirements. The housing requirement projections resulted in annual informal housing subdivision construction projects necessary to meet the anticipated need. Interviews with the city planning staff revealed that no other major government or private development projects were anticipated over the duration of the study time frame.

The resultant list of approximately 300 "future projects" (200 AFB projects and 100 city projects) was evaluated through application of Steps 4 through 8 of the RFFA determination method in Figure 9.2. The evaluation of AFB informal proposals and city formal and informal proposals for Steps 4 through 6 were relatively simple. All AFB informal proposals were identified within existing development program categories (e.g., pavement improvement plan projects), therefore, connections were easily identified. City formal proposals were identified in goal-oriented planning documents applicable within the defined boundaries, and informal proposals were developed from the planning document trend projections. From this list, in Step 7 of Figure 9.2, a total of 145 RFFAs were identified where air emissions were expected and could be estimated and quantified. However, the original list of 300 future projects could be

Table 9.2: Sample Calculations for Population and Dwelling Unit Projections

1. Project Future Populations

From city growth trends report:

Year	Population
1980	94,201
1990	96,259
1996	102,790

Report shows that the city has experienced steady population increases from 1990 to 1996 with no period of decline.

Average annual increase (1990-1996) = (102,790 - 96,259)/6 ≅ 1088 people/yr

Assuming trend continues...

Year		Population
1997	102,790 + 1088 =	103,878
1998	103,878 + 1088 =	104,966
1999	104,966 + 1088 =	106,054
⋮	⋮ ⋮	⋮

2. Project Future Dwelling Unit Volumes

From city growth trends report:

- Net change in city dwelling units for 1985 to 1995 = +1,408
- 1996 total city dwelling units = 41,259

Average annual dwelling unit increase = 1408/10 ≅ 141 units/yr

Assuming trend continues...

Year		Dwelling Units
1997	41,259 + 141 =	41,400
1998	41,400 + 141 =	41,541
1999	41,541 + 141 =	41,682
⋮	⋮ ⋮	⋮

used when considering other media (water, soil, socio-economics, etc.) effects within a complete CEA.

STEP 4 -- BASELINE AMBIENT AIR QUALITY DETERMINATIONS

Step 4 of the CAQEA method (Table 9.1) involves the determination of baseline ambient air quality and the identification of applicable standards. From the U.S. Environmental Protection Agency (USEPA) Aerometric Information Retrieval System (AIRS), it was determined that the study area was represented by one PM_{10} monitoring station with an annual average concentration of 19 $\mu g/m^3$. The area is considered to be in attainment for all criteria pollutants; however, observed data was not available for the other pollutants. Air quality information can also be obtained from the USEPA regional office with jurisdiction over the study area. Lack of ambient monitoring data is a situation common to several areas across the United States; nonetheless, information can be obtained, or developed, to represent (or be indicative of) current conditions. One approach is to conduct a complete emissions inventory for the area determined by the spatial boundaries. Once the emission inventory for the area is complete, either the inventory itself can be used as the baseline for comparing future events to current conditions, or modeling tools can be employed to estimate the ambient concentrations. Methods for the development of the emission inventory for the current conditions, or modeling tools can be employed to estimate the ambient concentrations. Methods for the development of the emission inventory for the current conditions, as well as future activities, are presented in the discussion of Step 5.

STEP 5 -- EMISSION ESTIMATES

Step 5 is focused on the development of quantitative and qualitative emissions estimates for the activities included in the analysis. To present a cumulative perspective, the operational effect of these actions must be included as well as the construction phase effects. Additionally, these effects should be presented in context with other activities in the area that produce measurable air quality effects.

For this example, the emissions estimates, both for the initial existing conditions and for the future year projections, were segregated into construction and operational activities for both the city and the AFB. Emission estimates were compiled for five pollutants: carbon monoxide (CO), volatile organic compounds (VOCs), oxides of nitrogen (NO_x), sulfur oxides (SO_x), and particulates (PM_{10}). VOCs estimates were compiled as an ozone (O_3) indicator, while particulate lead was omitted due to its low level of concern within the subject area. Emissions from stationary sources were estimated using information found in *Compilation of Air Pollution Emission Factors (AP-42), Volume I, Stationary, Point, and Area Sources* (USEPA, 1995) *and Supplement B to Compilation of Air Pollution Emission Factors (AP-42), Volume I, Stationary, Point, and Area Sources* (USEPA, 1996). Following the presentation of the developed emission inventory summaries, the remaining sub-sections under Step 5 provide examples of emission-related information on various source categories.

Annual Summaries

Once the emissions estimates were developed for the operational and construction activities within the spatial and temporal boundaries, the cumulative emission estimates were organized into chronological sequence. Annual summary periods were selected based on the level of detail of

information provided. Project proposal information collected was categorized by either calendar or fiscal year. For calendar year (CY) based proposals, it was assumed that all construction emissions could be applied to the CY in which the project was scheduled. Operational emissions resulting from those proposals were applied in the year immediately following the construction year and every year thereafter for the remainder of the study period. Fiscal year projections are linked to budgetary allotments. The U.S. federal government fiscal year (FY) begins on October 1 and ends on September 30. For example, FY98 begins October 1, 1997 and runs through September 30, 1998. Typically, funding for projects is not released to AFBs until the second quarter of the FY (e.g., January-March 1998). Due to time requirements for bid solicitation, contract award, and material delivery and staging, construction emissions resulting from FY projected proposals were applied to the CY after the FY (e.g., FY97 project construction emissions in CY98). The resulting operational emissions could be applied in the same manner as for CY proposals.

Table 9.3 presents a sample annual summary (1996) for the study area. The key contributors to the emission levels resulting from city activities include operational activities such as on-road vehicle use, stationary source industrial emissions, and off-road small engine operations. The key AFB operational activities include aircraft operations, on-road vehicle use, and stationary source operations. For both the city and the AFB, the primary construction activity emission source was pavement construction.

Operational Activities -- Major Sources

Development of the cumulative emission estimate began with the current stationary source emission inventory for the AFB. Incorporation of this existing document saves time and provides information on specific activities that may be useful as surrogate data for future activity emissions. The emission inventory for an AFB can be obtained from the air quality manager in the base environmental compliance office.

Major stationary source emissions for the city, or other federal facility, activities may be obtained either through the state air quality office or through the USEPA regional office. Depending on the level of detail requested on individual sources it may be necessary to process a Freedom of Information Act (FOIA) request. Some states, however, maintain a separate document, or data file, containing summary emission data for each major source. This document, if available, can be obtained without a FOIA request. The state summary document used for this study provided both the actual and allowed emissions for each source and pollutant, and included sources where emission inventories had not been completed (TNRCC, 1997). Where no emission inventory had been completed and only the allowed emissions were reported, these allowed emissions were used in the development of the cumulative inventory. Also, the state summary only provided the most current data available. For example, if one source reported actual emissions for 1994, 1995, and 1996 and another for 1993 only, the summary report provided the 1996 emissions from the first source combined with the 1993 emissions from the second source. While this data may be inaccurate as to current emissions, it was the best information available.

Operational Activities -- Vehicles

One of the largest air emission source categories in the study area is vehicle operations. Since vehicles are mobile sources, they are not

Table 9.3: 1996 Emissions Summary in the Defined Spatial Boundaries

	CO (lbs)	VOC (lbs)	NOx (lbs)	SOx (lbs)	PM10(lbs)
AFB Operation Sources					
Vehicles	694625	73682	60142	0	49146
T-37 Trim	8707	1106	179	88	32
T-37 LTO	536585	53459	18974	7397	1522
T-37 T&G	1071909	24338	77796	25268	402
T-38/AT-38 Trim	28877	4046	625	328	6
T-38/AT-38 LTO	2269369	329192	43603	23483	401
T-38/AT-38 T&G	2429602	131333	158250	69680	918
Emission Inventory	53614	162044	66252	25571	19135
4-Stroke Engines	54245	4837	616	74	88
Residential NG Use	4288	1179	10076	64	1198
Sub-Total (lbs)	7151821	785216	436513	151953	72848
AFB Construction Sources					
Water System	1910	145	548	50	153
Electrical System	6112	464	1752	160	488
New Construction	1070	81	307	28	85
Pavements	76591	15057	21955	2005	6115
Roofing	0	3136	0	0	0
Sub-Total (lbs)	85683	18883	24562	2243	6841
AFB Total (tons)	3619	402	231	77	40
City Operations Sources					
Vehicles	16631138	1468533	1958044	0	1910072
Commuter Aircraft	15438	18976	2821	430	1017
Emission Summary	3000687	485947	12650020	1482456	418526
4-Stroke Engines	1737643	154932	19742	2365	2820
Comm/Consum VOC	0	1613803	0	0	0
Comm/Res NG Use	128750	43750	492500	3000	58975
Sub-Total (lbs)	21513656	3785941	15123127	1488251	2391410
City Construction Sources					
Pavements	109061	78644	31262	2855	8708
Sub-Total (lbs)	109061	78644	31262	2855	8708
City Total (tons)	10811	1932	7577	746	1200
Entire Study Area					
Total (tons)	14430	2334	7808	823	1240

included in stationary source emission inventories; therefore, separate estimates were developed. Factors for calculating CO, VOC, NO_x, and PM_{10} emissions are available in the *Compilation of Air Pollution Emission Factors (AP-42), Volume II: Mobile Sources* (USEPA, 1985) and *Supplement A to Compilation of Air Pollution Emission Factors (AP-42): Volume II: Mobile Sources* (USEPA, 1991b). These emission factors are based on vehicle type and number of vehicle miles traveled (VMT). To calculate the emissions for the vehicle use in a given area for a specific time period, the information requirements are: the VMT for the period of concern; the type and age of vehicles used; and the fraction of the VMT that can be attributed to each vehicle type. AP-42 provides emission factor information for eight different vehicle types of various ages with multiple adjustment factors for such considerations as: percent cold start versus hot start; temperature and altitude variations; average speed; and potential for improper fuel use. Additionally, the road surface itself can be considered as a source for fugitive dust emissions resulting from vehicle traffic. PM_{10} estimations can be developed for fugitive dust from both paved and unpaved road surfaces based on data and methods provided in AP-42.

For this example, VMT and number of vehicles for the entire county (excluding the AFB) was obtained from the state Department of Transportation. No information was available regarding vehicle type and age. Population figures for the county and city from the growth trend report were used to determine the number of vehicles in the city by ratio to the city population. The national average and type tables and emission sensitivity tables provided in AP-42 were used due to the lack of specific vehicle fleet mix data.

If the VMT is not readily available for the study area, such as for the AFB, it can be determined via an area traffic study. Traffic studies can typically be obtained from the AFB or city traffic engineer or planner for the relevant areas. In this example, a traffic study was identified for use in developing a VMT estimate for the AFB. As discussed in Beaton et al. (1982), traffic counts at each roadway section of concern can be multiplied by the length of the roadway segment to determine the VMT for that segment. Adding the VMT for each segment provides the VMT data for the total area needed for the previously discussed calculations (USEPA, 1991a).

Operational Activities -- Aircraft

Aircraft emissions are an important component of the emission inventory when there is major air traffic such as for an AFB with an active flight line or a city with a commercial airport. AP-42 provides emission factors for several aircraft types, however, the military listings are incomplete. Additional emission factor information for military aircraft can be found in *Calculation Methods for Criteria Air Pollutant Emission Inventories* by Jagielski and O'Brien (1994). One important consideration when developing the estimates is that aircraft engine maintenance and testing operations need to be included where appropriate. For this example, the municipal airport is not a major hub and little if any maintenance is performed. For those aircraft activities only the landing-and-takeoff (LTO) cycles are included as mobile source contributions.

The AFB, however, conducts routine testing and maintenance of the aircraft operating from its flightline. Some of these activities, such as aerospace ground equipment (AGE) emissions and jet engine test cell emissions, were included in the base emissions inventory, and, therefore, did not require separate calculations. An additional maintenance activity

that is not accounted for in the base emission inventory is the conduction of aircraft trim operations where the engine power output levels are evaluated while the aircraft is held stationary. This activity differs from jet engine test cell operations in that the engine is not removed from the airframe. Aircraft maintenance personnel can be contacted to obtain trim operation statistics.

The calculation of LTOs for military aircraft is conducted in the same manner as for civilian aircraft with the appropriate emission factors and operating times for each specific engine. Additionally, Air Force training activities can include considerable emissions from touch-and-go (T&G) activities. Information such as the type and number of aircraft used at the AFB, the number of LTO and T&G operations conducted annually by each aircraft type, and the percentage of training versus operational sorties flown, was obtained from the base operations flight.

Construction Activities -- Source Categories

Typically, a NEPA analysis deals with the emissions resulting from new activities. These emissions are evaluated for both the construction and operation stages of a project and, occasionally, for the demolition stage. In a cumulative sense, construction, operation, and demolition phase emissions should be included for all activities within the spatial and temporal boundaries. The previously discussed operational emission estimates provide the operational stage emissions for the activities initiated prior to the study timeframe (e.g., the baseline emissions). The categories of projects evaluated include: water systems, sanitary sewer systems, storm drains, natural gas distribution systems, electrical distribution systems, facility disposals, pavements construction and repair, facility construction, roofing construction and repair, and housing development.

Construction Activities -- Pavements

Paving activities identified within the spatial and temporal boundaries included: asphalt or concrete pavement construction and repair, and runway striping. Striping emission estimates can be made through a simple estimation of the volume of paint used multiplied by the paint-specific VOC emission factors provided in AP-42. Concrete construction (entire existing roadway demolished and re-built) was estimated with the per-acre emission factors for fugitive dust and combustion sources as described for general construction activities. Concrete repair projects, identified where the entire roadway was not to be demolished and re-built, were estimated similar to the concrete construction projects except that the assumption was made that only 25% of the roadway would be demolished and rebuilt. The reasoning for this assumption was that if more than 25% of a road segment (e.g., paved area between two intersections) had failed, that segment would be identified for a complete re-build.

Asphalt paving projects were also segregated into repair and complete re-construction. If a road segment was to be repaired, emission estimates were based on the application of the asphalt overlay. For complete re-builds, asphalt emissions were combined with combustion emissions as described for concrete construction (AP-42 includes a section -- Section 4.5 -- on estimating emissions from asphalt paving operations).

The primary emissions from asphalt pavements are VOCs. Liquefied asphalts are used in tack-and seal operation, roadbed priming for hot-mix asphalt concrete application, and as the primary binder for small paving operations. Large paving activities typically rely on hot-mix asphalt

concrete which is created by heating asphalt cement and combining it with the aggregate (USEPA, 1995).

For this study, it was determined that hot-mix asphalt concrete was to be used for all AFB applications. Further, since the AFB and the city use the same local area pavement contractor, the assumption was made that asphalt emulsions would also be used for city projects. AP-42 emission factors are available for estimating long-term emissions from cutback asphalt applications. AP-42 does not, however, provide emission factor information regarding asphalt emulsion emissions. Emulsified asphalts consist of asphalt cement suspended in water containing an emulsifier. Based on information in Markwordt and Bunyard (1977), the lb/lb emission factors presented in AP-42 for cutback asphalt were modified for asphalt emulsions.

STEP 6 - DETERMINING THE CHANGE IN AIR QUALITY

Once the cumulative emissions had been estimated and summarized within the pre-determined boundaries, the change to the background conditions should be evaluated. There are two main options for the "change in air quality" analysis: evaluation of emission levels, and evaluation of ambient concentrations. Both options were used in this example; however, individual preference and the availability of background data could influence the choice.

Emission Levels

Given the emissions estimates from Step 5, the most expedient analysis approach is to evaluate the emission level changes anticipated from the proposed activities in the study area. Parameters that can be obtained from this level of analysis include comparisons of the AFB emissions with and without the proposals and comparison of the total area emissions with and without the proposed AFB activities. Figures 9.3 and 9.4 graphically present these comparisons for PM_{10} over the 10 year temporal boundaries for the study. PM_{10} was selected for presentation since ambient monitoring station data was available allowing for direct comparison of the emission level analysis to the ambient concentration level analysis. Separate graphs were generated to display the emission changes within the AFB boundaries and to display the effect of these activities on the total study area. The focus of a NEPA analysis is on federal activity effects, not private, local, or state activity effects. The information is presented in this format to emphasize the federal influence. If desired, the analysis focus can be easily shifted to present the effects on the area from alternate viewpoints such as city or state government influence.

Careful inspection of Figures 9.3 and 9.4 shows that the largest effects occur in 1997 and 2001. However, it is important to interpret this information in context with the availability of information for any given year. In the later years of the study period, the emission effects of the proposed activities appears to taper off. By 2005, the emissions appear to return to almost the same level as was predicted in the absence of the AFB projects' influence. Three points can be made with regard to this observation. First, while AFB development activities will exert a short term influence on the specific AFB and study area emissions, the long term, operational phase influence of those activities is minimal. Second, since the majority of the PM_{10} emissions increments identified in this example are caused by construction activity, not the operation of the proposed facility, it would be appropriate to focus PM_{10} mitigation efforts on the construction processes. This does not mean that the construction

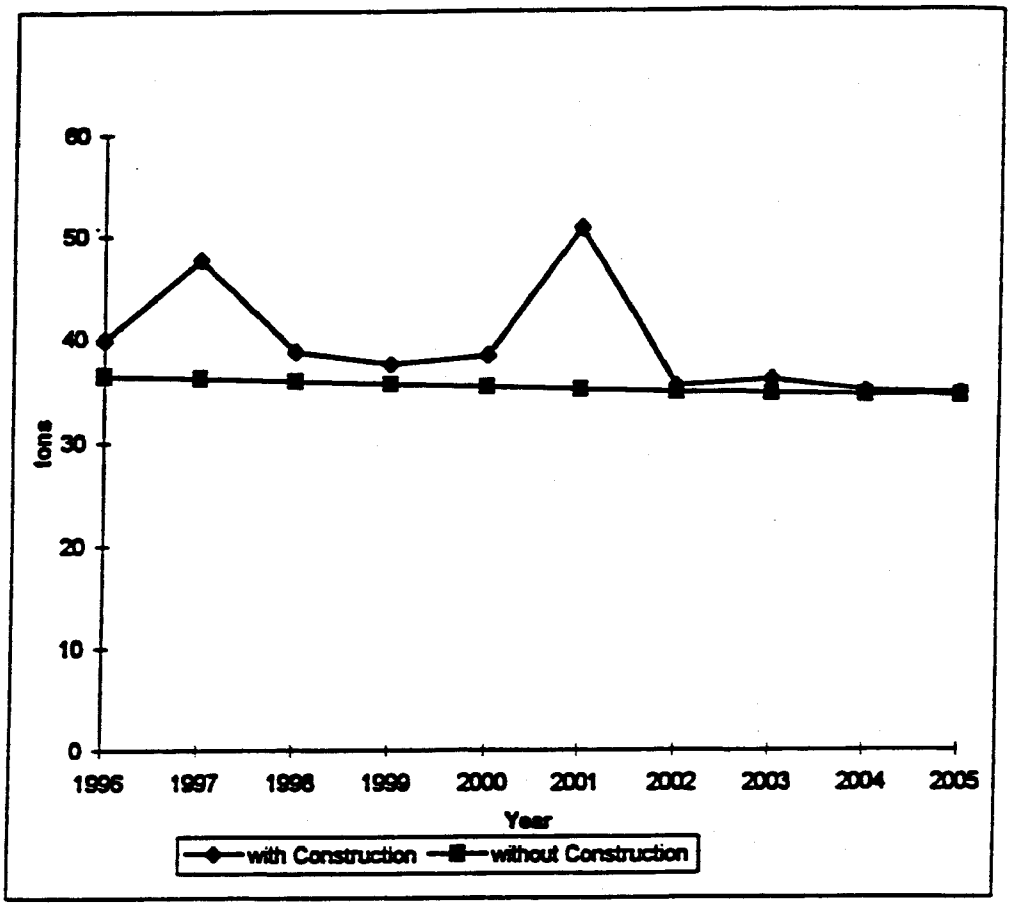

Figure 9.3: AFB PM10 Emissions Comparisons

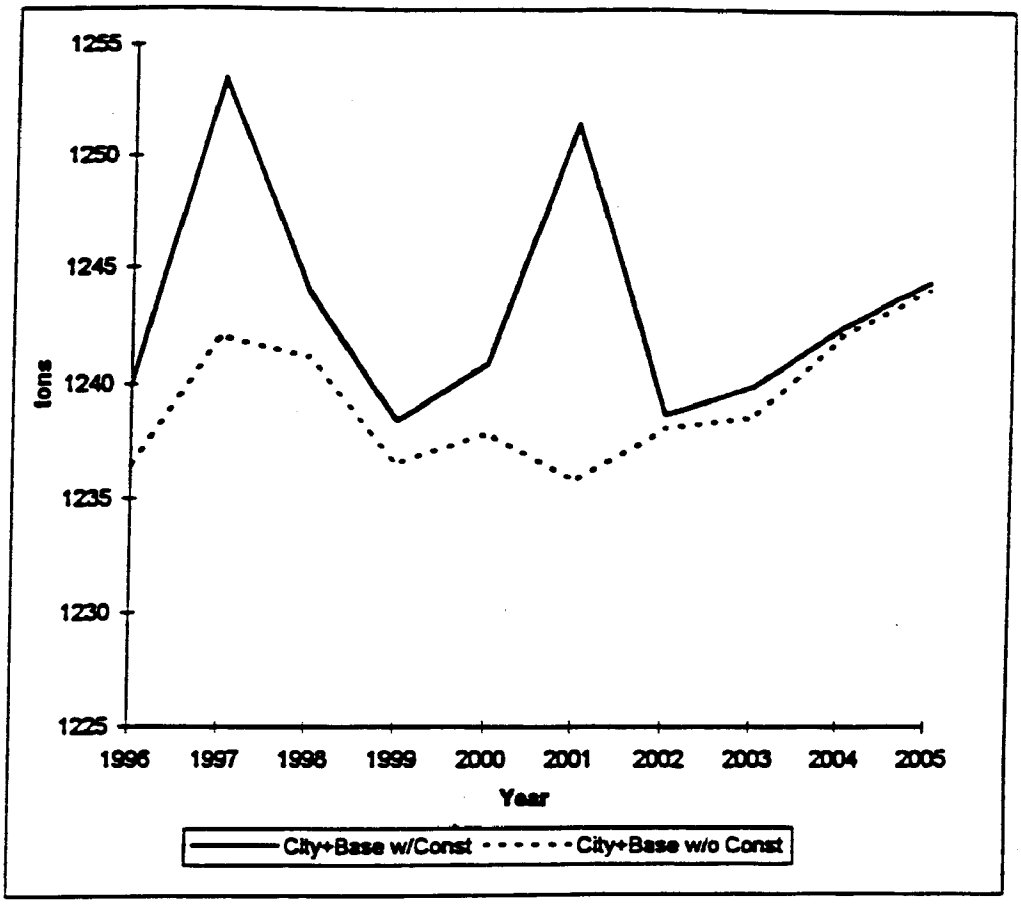

Figure 9.4: AFB Project Effect on PM10 Emissions in the Study Area

phase will be of primary importance for mitigation consideration in every example. The value is in the ability of the assessment tool to identify the appropriate focus. And third, it is unlikely that AFB development activities will simply end by the year 2005. A more reasonable explanation is that development proposals for the later years of this study and beyond have not yet, even informally, been formulated. Were this study to be re-evaluated at a later time, it is likely that additional RFFAs would be available for inclusion that would elevate the development activity construction emissions for the time period of 2002 through 2005 to those similar to the first four to five years of the study period.

The graphical analysis such as shown in Figures 9.3 and 9.4 can be used to present the cumulative effect of AFB development activity for individual pollutants. While this is valuable, the analysis can be enriched. A tabular presentation of the percentage increase in emission level, relative to each pollutant and year, can provide additional insight into effect significance and proper mitigation focus. Table 9.4 presents the percent increase in the emission level of each pollutant, annually, throughout the study timeframe within the AFB boundaries. Table 9.5 presents the same type of data for the AFB influence with respect to the total study area emissions.

The graphical analysis revealed that 2001 was one of the years with the most extreme effect for PM_{10} emissions. Table 9.4 shows that, within the year 2001, AFB CO emissions increase 5.09%, VOC emissions increase 4.34%, NO_x emissions increase 24.65%, SO_x emissions increase 6.14%, and PM_{10} emissions 44.74%. This indicates that the primary areas of concern for the AFB, with regard to its local air quality, would be to focus its mitigation efforts on both NO_x and PM_{10} emissions. However, when addressing the AFB influence on total study area emissions, the focus of concern shifts. Table 9.5 indicates that the 2001 AFB proposal emissions result in a 2.04% increase in CO, a 0.99% increase in VOC, a 0.76% increase in NO_x, a 0.68% in SO_x, and a 1.31% increase in PM_{10} emissions. From the total study area viewpoint, the primary pollutant of concern is CO. This demonstrates the importance of evaluating an activity's effect, not just on its immediate surroundings, but also with respect to the total study area setting.

Additionally, the evaluation of cumulative emissions can provide insight into more complex atmospheric issues such as acid deposition and photochemical oxidant formation. For example, several studies have indicated that sulfur oxides and nitrogen oxides are the principal precursors to acid deposition (Canter, 1997). Evaluation of the change in emission levels of these two pollutants within the study area, therefore, provides inferences as to the future potential for acid precipitation.

A qualitative relationship between the major chemical and atmospheric variables active in photochemical oxidant formation, which includes urban (tropospheric) ozone, can be expressed as (Cooper and Alley, 1994):

$$PPL = \frac{(ROG)\,(NO_x)\,(Light\ Intensity)\,(Temperature)}{(Wind\ Velocity)\,(Inversion\ Height)}$$

where:

PPL = photochemical pollution level
ROG = concentration of reactive organic gases (to include VOCs)
NO_x = concentration of oxides of nitrogen

Table 9.4: AFB Proposal Effects on AFB Emissions

Year	Pollutants (%)*				
	CO	VOC	NOx	SOx	PM10
1996	1.20	2.40	5.63	1.48	9.39
1997	3.64	3.02	17.46	4.49	31.47
1998	0.89	1.28	4.50	1.08	7.83
1999	0.58	1.64	3.09	0.70	5.23
2000	0.95	1.47	4.89	1.15	8.57
2001	5.09	4.34	24.65	6.14	44.74
2002	0.25	0.21	1.26	0.18	1.71
2003	0.50	0.38	2.43	0.47	3.88
2004	0.15	0.15	1.13	0.05	1.07
2005	0.12	0.14	1.03	0.02	0.87

*All percentages are increases in the emission levels over the 1996 emission levels (the base year chosen for this analysis without considering construction projects on the AFB)

Table 9.5: AFB Proposal Effects on Total Study Area Emissions

Year	Pollutants (%)*				
	CO	VOC	NOx	SOx	PM10
1996	0.40	0.49	0.16	0.15	0.29
1997	1.35	0.68	0.54	0.50	0.95
1998	0.34	0.29	0.14	0.12	0.23
1999	0.23	0.37	0.10	0.08	0.16
2000	0.38	0.34	0.15	0.13	0.25
2001	2.04	0.99	0.76	0.68	1.31
2002	0.10	0.05	0.04	0.02	0.05
2003	0.20	0.09	0.07	0.05	0.11
2004	0.06	0.03	0.03	0.01	0.03
2005	0.05	0.03	0.03	0.00	0.02

*All percentages are increases in the emission levels over the 1996 emission levels (the base year chosen for this analysis without considering construction projects on the AFB)

It is readily apparent from this qualitative model that increases in NO_x and VOC emissions have strong potential to increase tropospheric ozone concentrations. Further, evaluation of the VOC/NO_x ratio assists in focusing mitigation efforts (Wolff, 1993). When this ratio results in a value less than ten (VOC/NO_x < 10), the condition is called VOC limiting. When the ratio is greater than twenty (VOC/NO_x >20), the condition is called NO_x limiting. The optimal mitigation strategy for prevention or reduction of tropospheric ozone is to focus emission control efforts on the pollutant termed as the limiting factor. For this example, the ratio indicates that the study area condition is VOC limiting for all years addressed at both AFB and study area scales.

Ambient Concentrations

While an evaluation of changes in emission levels yields useful information, it does not provide the assessor with an estimate of when, or if, ambient air quality standards (AAQS) will be exceeded. In order to determine the change to the ambient concentration resulting from proposed activities, it is necessary to have observations or estimations of existing ambient concentrations. Ambient air quality monitoring data was collected for the study area in conjunction with Step 4; however, data were available only for PM_{10}. Since only one PM_{10} monitoring station was located within the study area, the average annual concentrations reported for this location were used as the average ambient concentration for the entire study area. It is not surprising, or uncommon, to find that ambient air quality monitoring data is less than complete for an area requiring NEPA analysis.

As proposed by Rumrill and Canter (1998a), cumulative air quality effects can be quantified and analyzed with the assistance of simple techniques such as rollback, simple area source, and box models. The available data was compared to the input requirements of each model type, and it was determined that the box model was the most appropriate for the data collection for this example. No implication is intended as to the suitability of the other two model types for cumulative assessments. Other studies may find one of the others to be more suitable.

Multiple equations are available for box modeling. For example, Gifford and Hanna demonstrated the utility of box model application to long term urban air quality analysis as follows (Benarie, 1980):

$$X = c\frac{Q}{A\bar{u}}$$

where:

- X = the ambient concentration ($\mu g/m^3$)
- Q = the total area emissions ($\mu g/sec$)
- A = the area (m^2)
- $\bar{u}$ = the annual average wind speed (m/sec), and
- c = a correction factor applied in a model calibration exercise

The correction factor is needed to account for inherent assumption errors. Box models assume that the pollutant emissions are uniformly mixed in the entire volume of air. While some mixing will occur, factors such as the location of emission sources (ground level) cause the actual pollutant distribution to be non-uniform with the highest concentrations near the emission sources.

The desired comparison in ambient air quality modeling is to relate the predicted concentrations to the observed values from monitoring

stations. Monitoring stations are typically located so that the average pollutant concentration respirated by the human population can be determined. In other words, monitoring stations tend to be located near ground level emission sources. Placement heights required by the USEPA for CO, O_3, NO_2, SO_2, and PM_{10} monitoring stations range from 2 to 15 meters above ground level (USEPA, 1991a).

Gifford and Hanna demonstrated their application of the box model in 29 major urban areas for both SO_2 and particulate matter to determine annual average concentrations (Benarie, 1980). Using ambient air quality monitoring data for calibration, they found that an average correction factor of 50 should be applied for SO_2 and 202 for particulates. The reason given for the difference in the correction factor between the two pollutants was that the sulfur dioxide emissions accounted for in the respective inventories included a large fraction associated with tall stacks (Benarie, 1980). Emissions from these tall stacks would disperse differently than emissions from ground level sources and therefore, this would reflect on the concentrations observed at the monitoring stations. The correction factors obtained for each city varied for particulates from a low of 57 to over 600. Similar variation was found in correction factors for sulfur dioxide. These box model applications were all applied to large urban centers. Finally, in a related study, Wu found that, for small urban areas, an average particulate matter correction factor of 892 was more appropriate (Benarie, 1980).

This current study was performed on an urban area (population in the range of 100,000) that can easily be categorized as small. Table 9.6 presents the 1996 annual average concentrations calculated for PM_{10} with the influence of the proposed base activities using the same form of the box model as Gifford and Hanna. Table 9.7 presents the calculations for the determination of an appropriate correction factor for this study and its application to future emission projections. The correction factor determined here (807) compares well to the average for small urban sources (892) developed by Wu (Benarie, 1980), assuming that the proportion of PM_{10} in particulate matter remains relatively constant over the analysis. The largest annual PM_{10} increase over the 10 year period is 0.24 $\mu g/m^3$.

The analysis of air quality effects resulting from federal activities is often required in areas where ambient air quality monitoring data is not available. In such cases, the average correction factors for the appropriate urban center size, as determined by Gifford and Hanna, and later by Wu, could be applied. These values are, however, averages. Application of an average value to a specific situation introduces the additional error of the degree of difference between the application site and average conditions. However, this approach can provide the assessor with a sense of the "order of magnitude" of relative change on ambient air quality resulting from the proposed activities. On the other hand, the predicted values should not be accepted as truly representative of the actual future concentrations. The average correction factors should only be used to determine the trend (e.g., increasing, decreasing, stable) in the ambient concentration resulting from the proposed activities.

Although not addressed in this example, this modeling procedure can also be applied to the evaluation of long-range transport effects. Downwind transport determinations should be made where there is some considerable effect on ambient air quality, or where concern is expressed over pollutant transport to a new location. To evaluate this effect, the study area can be modified to include the downwind receptor location, and the ambient concentrations can be recalculated using only the source emission contributions from the original study area as shown in Figure 9.5. This will not provide the assessor with an accurate prediction of the actual ambient concentration at the downwind area. It will, however,

Table 9.6: Uncalibrated Gifford and Hanna Box Model Calculations

Available Information

1996 Total PM_{10} Emissions = 2,479,807 lbs/yr (from Table 9.3)
Local Annual Average Wind Speed = 5.66 m/s (from local weather data)
City Plus AFB Area Dimension - x (windward) = 18,288 m
- y (crosswind) = 14,630 m

Using the uncorrected equation:

$$X = \frac{Q}{Au}$$

2,479,807 lbs/yr = 35,661,752 μg/s

X = (35,661,752)/(18,288 x 14,630 x 5.66) = 0.02355 μg/m^3

Using the [redacted]corrected equation:

$$X = c\frac{Q}{Au}$$

c = 202 (based on study of 29 urban areas, many of which were larger than the urban area in this example

X = (202)(0.02355) = 4.56 μg/m^3

Table 9.7: Calibrated Box Model Results for PM_{10}

Using the equation:

$$X = c\frac{Q}{Au}$$

Set $X = 19\ \mu g/m^3$

Solving the equation for c with the 1996 data (0.02355 $\mu g/m^3$ from Table 9.6):

$$c = 806.8 \cong 807$$

Applying this equation with the correction factor to the projected PM_{10} emissions throughout the study period yields the following results:

Year	Projected Ambient Concentration With Proposed AFB Activities ($\mu g/m^3$)	Projected Ambient Concentration Without Proposed AFB Activities ($\mu g/m^3$)	Increase ($\mu g/m^3$)
1996	19.00	18.95	0.05
1997	19.21	19.04	0.17
1998	19.07	19.02	0.05
1999	18.98	18.95	0.03
2000	19.02	18.97	0.05
2001	19.18	18.94	0.24
2002	18.99	18.98	0.01
2003	19.01	18.98	0.03
2004	19.04	19.04	0.00
2005	19.07	19.07	0.00

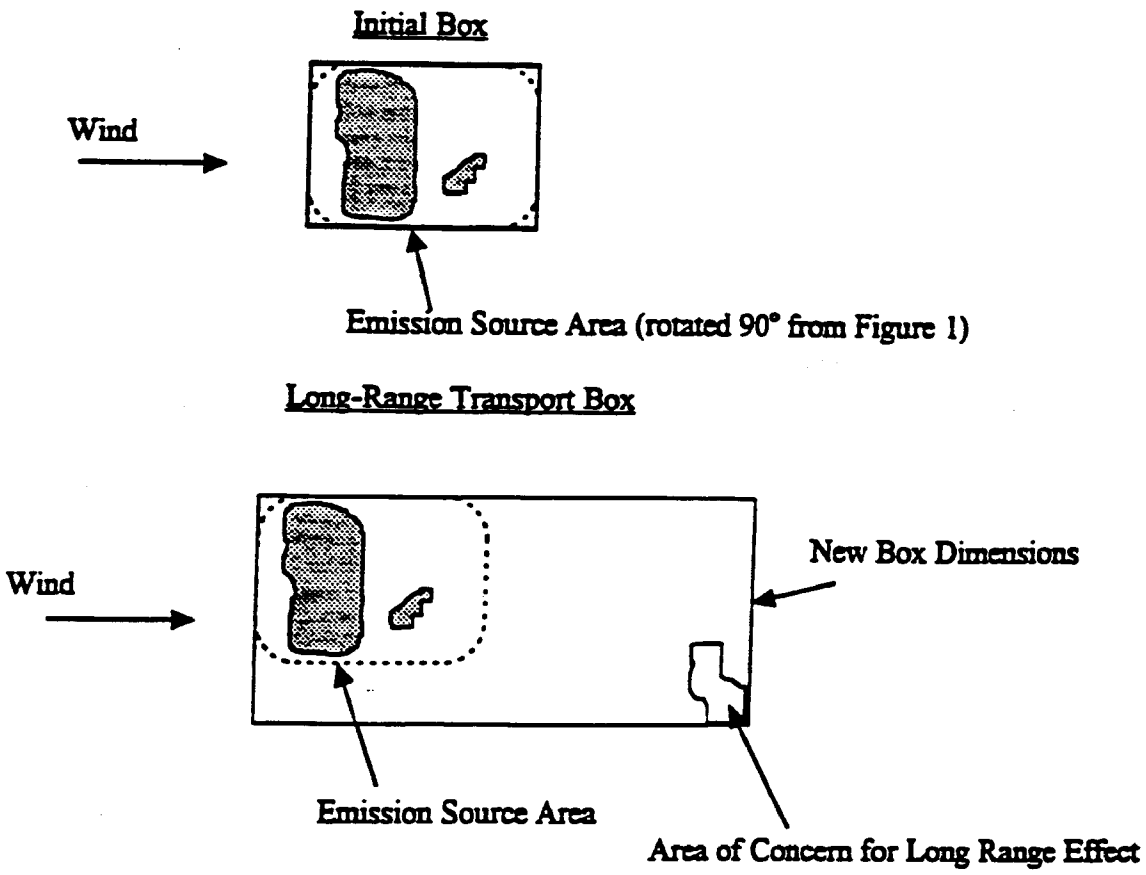

Figure 9.5: Long Range Pollutant Transport Analysis

allow the determination of the study area's contribution to the overall air quality in the downwind area. With ambient data obtained relative to this new receptor, the percentage contribution resulting from the study area activities can be determined.

STEP 7 -- SIGNIFICANCE DETERMINATION

see pages 2-10 & 2-14

The significance of these predicted cumulative air quality effects can be interpreted via the multi-criteria decision making method developed by Rumrill and Canter (1998c). Recommendations for rating factor intensities are shown in Table 9.8. Based on these recommendations, Table 9.9 presents the intensity ratings for the data collected and developed in this example relative to AFB level PM_{10} emissions. Table 9.10 presents the factor weights and matrix calculations to determine the "weighted effect" significance score for PM_{10} relative to the AFB boundaries. Table 9.11 presents the "weighted effects" for each pollutant and boundary condition (AFB and total study area) to demonstrate the change in significance based on perspective.

From Table 9.11, it can be concluded that the cumulative air quality effects are not significant. Standard practices for limiting air pollutant emissions were identified in the emissions calculation portion of the assessment (Step 5). Calculations were based on the assumption that these measures would be employed. However, the significance determinations were made with the assumption that no further mitigation efforts would be applied to the predicted emissions.

The significance rating matrix (Tables 9.8 and 9.10) was designed generically for widespread application. For this particular application, some data was not available. For example, in all but one case (PM_{10}), no ambient concentration information was available for use in the "Ambient Air Quality Standards" portion of the matrix. Ambient data was not available due to the lack of monitoring stations in the area. However, discussions with state environmental regulators led to the conclusion that there were no ambient concentrations of concern relative to the unmonitored pollutants (CO, VOC, NO_x, and SO_x). Comparisons of available ambient data for PM_{10} were made to the national standard (50 $\mu g/m^3$ annual average) since the state and local standards were not more restrictive. Additionally, the permit compliance status of the local industrial sources is confidential information. Since this factor cannot be interpreted as an indication of total compliance or partial noncompliance, no assessment of percentage of noncompliance with permits could be made for the total area. The AFB was determined to be in compliance with all permit limitations.

Public concern was evaluated by interviewing city and AFB personnel responsible for public meetings on development issues. The environmental office in the Civil Engineer Squadron at the AFB was contacted for public opinions on development issues, and the city planning office was contacted for public opinions on developments in the entire study area. Both offices stated that the public has expressed very little concern over air quality issues; however, the topic is occasionally broached.

STEP 8 -- MITIGATION OPPORTUNITIES

Opportunities for mitigation can be determined and evaluated by applying the method discussed in Rumrill and Canter (1998c). Since the primary influence on air quality occurs during the construction stage of the activities presented in this example, it would be appropriate to focus mitigation attention on construction procedures and construction equipment

Table 9.8: Factor Intensity Ratings for Cumulative Air Quality Effects

Factor	Cumulative Intensity		
	High (3)	Moderate (2)	Low (1)
Pollutant Emissions - % change in emission level	10% or greater increase	5 - 9% increase	< 5% increase
- timing, duration, and rate of change	occurs early in study period, > 5 years duration, high rate of increase	occurs midway through study period, 1 - 5 years duration, moderate rate of increase	occurs late in study period, < 1 year duration, slow rate of increase
- comparison to emission limitations (% noncompliance)	10% or greater	5 - 9%	< 5%
Ambient Air Quality Standards - change in ambient concentration	> 5% increase	1 - 5% increase	< 1% increase
- timing, duration, and rate of change	occurs early in study period, > 5 years duration, high rate of increase	occurs midway through study period, 1 - 5 years duration, moderate rate of increase	occurs late in study period, < 1 year duration, slow rate of increase
- violation of standards	cause new violation	impairs plans to mitigate existing violation	small contribution to existing violation
- influence on air pollution episodes	new occurrence where none observed before or large increase in existing number of episodes	moderate increase in existing episode frequency or required level of response	small increase in existing episode frequency or required level of response
- influence on current area classification	exceeds classification based limits	classification based limits reached	limits future development
Public Perception - level of public concern	high level of concern expressed	some concern expressed	little concern expressed
Secondary/Indirect/Synergistic Effects - influence on PPL potential	10% or greater increase in precursor emissions	5 - 9% increase in precursor emissions	< 5% increase in precursor emissions
- influence on VOC/NO_x ratio	10% or greater increase to limiting pollutant or change of limiting pollutant	5 - 9% increase to limiting pollutant	< 5% increase to limiting pollutant
- influence on stratospheric ozone	large increase in ODC emissions	moderate increase in ODC emissions	small increase in ODC emissions
- influence on global warming	large increase in precursor emissions	moderate increase in precursor emissions	small increase in precursor emissions
- spatial (transboundary) transport	large contribution to downwind area concentration	moderate contribution to downwind area concentration	small contribution to downwind area concentration
- influence on acid deposition potential	large increase in precursor emissions	moderate increase in precursor emissions	small increase in precursor emissions
Human Health - level of carcinogenic effect	known human carcinogen	probable human carcinogen	possible human carcinogen
- level of non-carcinogenic effect (dose response relationships, comparison to thresholds, synergisms, etc.)	Air Toxics - concentration above MAAC (or TLV/1000) Others - high likelihood of adverse effect	Air Toxics - concentration at MAAC (or TLV/1000) Others - moderate likelihood of adverse effect	Air Toxics - measurable conc. below MAAC (or TLV/1000) Others - low but identifiable possibility of adverse effect
Mitigation - timing/focus of mitigation vs. timing/focus of effects	allows for long-term (>5 years) continuance of mitigable effect	allows for continuance of mitigable effect for 1 - 5 years	allows for continuance of mitigable effect for less than one year

ODC = Ozone Depleting Chemical, MAAC = Maximum Allowable Ambient Concentration, TLV = Threshold Limit Value

Note: Shift in pollutant of concern factor intensity ratings not included (addressed through separate ratings for each spatial boundary condition)

Table 9.9 : Factor Intensity Ratings for AFB Level PM_{10}

Factor	Analysis Data	Cumulative Intensity Rating
Pollutant Emissions - % change in emission level	at least 1 year has >10% increase (44.74% highest noted in Table 4)	3
- timing, duration, and rate of change	Figure 3 shows 2 peaks of moderate increase, one early and one midway through the study, each lasts for 1 year	2
- comparison to emission limitations (% noncompliance)	all compliance limits met	0
Ambient Air Quality Standards - change in ambient concentration	<1% increase across study timeframe (0.24 $\mu g/m^3$ highest noted in Table 7)	1
- timing, duration, and rate of change	extremely slow increases observed in initial half of study period (see Table 7)	1
- violation of standards	no violations	0
- influence on air pollution episodes	no episodes expected	0
- influence on current area classification	no predicted limitations on development or change in classification	0
Public Perception - level of public concern	subject occasionally broached in meetings, small level of concern	1
Secondary/Indirect/Synergistic Effects - influence on PPL potential	N/A	0
- influence on VOC/NO_x ratio	N/A	0
- influence on stratospheric ozone	not an ODC	0
- influence on global warming	not a precursor	0
- spatial (transboundary) transport	small contribution to nearby downwind areas	1
- influence on acid deposition potential	not a primary precursor	0
Human Health - level of carcinogenic effect	not a carcinogen	0
- level of non-carcinogenic effect (dose response relationships, comparison to thresholds, synergisms, etc.)	concentration low but measurable, synergisms with sulfates could produce some effects	1
Mitigation - timing/focus of mitigation vs. timing/focus of effects	effect continues throughout study period (>5 years) - study assumes no additional mitigation beyond standard construction and operation practices	3

ODC = Ozone Depleting Chemical, MAAC = Maximum Allowable Ambient Concentration, TLV = Threshold Limit Value

Table 9.10: Significance Rating for AFB Level PM_{10}

Factors	Factor Weighting (a) High importance = 3 Medium importance = 2 Low importance = 1	Cumulative Effect Intensity (b) Large Adverse = 3 Moderate Adverse = 2 Small Adverse = 1 No Adverse Effect or Beneficial Effect = 0	Weighted Effect (axb)
Pollutant Emissions			
% change in emission level	2	3	6
timing, duration, and rate of change	2	3	6
comparison to emission limitations (% noncompliance)	2	0	0
Ambient Air Quality Standards			
change in ambient concentration	2	1	2
timing, duration, and rate of change	2	1	2
violation of standards	3	0	0
influence on air pollution episodes	2	0	0
influence on current area classification	2	0	0
Public Perception			
level of public concern	3	1	3
Secondary/Indirect/Synergistic Effects			
influence on PPL potential	2	0	0
influence on VOC/NO_x ratio	2	0	0
influence on stratospheric ozone	1	0	0
influence on global warming	1	0	0
spatial (transboundary) transport	2	1	2
influence on acid deposition potential	2	0	0
Human Health			
level of carcinogistic effect	2	0	0
level of non-carcinogistic effect	2	1	2
Mitigation			
timing/focus of mitigation vs. timing/focus of effects	2	3	6
			Total = 29

Note: The factor weightings are considered to be generic and are explained elsewhere (Rumrill and Canter, 1998c). The intensity ratings are from Table 9.9.

Table 9.11: Weighted Effects Comparisons for Air Quality Cumulative Effects

Pollutant	AFB	Total Study Area
CO	19	15
VOC	21	19
NO_x	29	19
SO_x	21	17
PM_{10}	29*	19

Note: Possible range of values – 0 - 35 (low significance or nonsignificant)
36 - 72 (moderate degree of significance)
73 - 108 (high level of significance)

*Basis is shown in Table 9.10; bases for other weighted effects are available elsewhere (Rumrill, 1998).

emission control. However, since it was determined that there would be no significant effect on air quality resulting from these development activities, it may be prudent to focus additional mitigation resources on environmental resources other than air quality.

SUMMARY AND CONCLUSIONS

This case study has presented an application of proposed methods (Table 9.1 and Figure 9.2) to a real world example. The intent was to validate the previously proposed methods as well as to demonstrate the practicalities of air quality CEA. This study presents the details and assumptions of each step of the analysis. Presentation in this format demonstrates the value of the assessment methods in context with their limitations in real world application.

Once this type of study has been conducted for a specified region, it can be incorporated into the formal development planning documents of both the city and the federal installation. Current practice in development planning recommends a section discussing the environmental resources of the planned area. Regarding this case study, the Air Force has included such discussions in its comprehensive development planning documents as have city planning agencies. The addition of a CEA component into these documents seems logical and desirable.

Once the CEA study is formalized, either as a section of a comprehensive plan or as a separate document, it can be referenced in project-specific environmental impact studies conducted on the included activities. These project-specific studies may lead to environmental assessments (EAs) or environmental impact statements (EISs). If new project proposals are planned, the CEA can be easily updated to incorporate the relevant effects. When conducting the individual project assessments, the requirements for CEA can be adequately addressed by discussing only the relevant quantitative and qualitative results, their influence on significance determinations, and the additional mitigation opportunities as determined here. The net result would be a more complete NEPA document (either an EA or EIS) for the project proposal without a noticeable increase in volume.

The CAQEA study should be reviewed and updated on a time schedule appropriate to the development planning pace of the assessed area. Open communication between the federal agency planning office and the city planning office can facilitate the time schedule necessary to ensure updates are performed adequately.

In summary, this study has provided a practical example of the application of a step-wise approach for cumulative air quality effects. To that end, the following observations and conclusions can be drawn:

(1) This analysis represents only one component of an overall CEA addressing all media. It is intended to be maintained as an independent document or possibly an appendix to a community development plan. It will require periodic updates as conditions change or new information is obtained, possibly on an annual or biennial basis. And, it is envisioned that the results of this study would be incorporated by reference into each relevant EA or EIS conducted at the AFB.

(2) Assessors should not restrict themselves to following the exact order of the method steps. The step sequences are intended to guide the assessor's thought processes, not

dictate the chronology of step applications. It can be useful to revisit steps as new information becomes available.

(3) Quantitative analysis results can shift the focus with respect to the pollutant of concern when the spatial or temporal context is varied.

(4) Caution should be used when applying average, or surrogate, correction factors when calibrating dispersion models. This approach can introduce an additional potential for error that may limit the value of the resultant predictions.

(5) Projections of activity proposals and their effects become increasingly more uncertain as the future time boundary is extended. Firm commitments to development activities far into the future is rare, and to estimate emissions from uncertain future proposals can lead to inaccuracies in future emission levels or ambient air quality concentrations. However, failure to include these more speculative possibilities can lead to the erroneous conclusion that emission levels will decline in the future. Regardless of the approach taken, the assessor should be aware of the probability that far reaching future plans will likely be modified as the timeframe draws closer.

(6) Public participation can be directly incorporated into this analysis process during the application of the factor weights and effects intensity ratings. By default, public involvement is also incorporated in this analysis through its inclusion in the preparation process of any community planning documents utilized, and during the individual project EIA process for each activity that incorporates this analysis.

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CHAPTER 10

EFFLUENT TRADING PROGRAMS -- AVAILABLE INFORMATION AND EXPANDING MITIGATION OPTIONS FOR SURFACE WATER QUALITY IMPACTS*

Historical approaches to air and water pollutant emissions reductions have focused on "command-and-control" involving technologies designed for pollutant types, characteristics, and quantities. Air and water quality laws and regulations have traditionally specified emission and ambient standards and delineated control technologies. Emission (or effluent) standards relate to air or water pollutants released to the environment, while ambient standards focus on air and water quality. Pollutant emission sources are subject to compliance with emission standards; and further, their emissions should not cause violations of ambient standards. However, when emissions are too close together spatially and/or temporally, nonattainment problems can be created regarding ambient standards even though all contributing sources are in compliance with their respective emission standards. Accordingly, pollutant emission reductions which are greater than those required for emission standards compliance may be necessary. In these situations relative to surface water quality management, an alternative market-based approach involving "effluent trading programs" (ETPs) may be more cost-effective than command-and-control (U.S. Environmental Protection Agency, 1996; Hester, et al., 1997; and Jarvie and Solomon, 1998). These types of situations can result from the undesirable cumulative effects of development projects in defined watersheds.

A key component of successful ETPs is the incorporation of requirements for examining the water quality and aquatic ecosystem impacts of proposed trades as well as the cumulative effects of the overall trading program. This component is thus analogous to ETPs having an environmental impact assessment (EIA) requirement. Accordingly, these impact analysis requirements are similar to conducting a "focused" study on the surface water impacts of development projects, irrespective of the existence of an ETP. Both ETPs and surface water-related environmental impact studies require information, prediction, and interpretation (assessment) of the potential consequences of actions (trades or development projects). Further, ETPs can expand the range of mitigation options available for existing and proposed development projects with surface water quality impacts.

The premise of this chapter is that mutual benefits can accrue to development projects with EIA requirements which are located in geographical areas with ETPs. Further, consideration of the cumulative water quality effects of developments in an area without an ETP could lead to the planning and implementation of such a program. These symbiotic relationships are addressed herein via sections on the fundamentals of

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*This chapter is largely based on the following paper: Canter, L.W., Edwards, A.J., and Szekely, F., "EIA and Emissions (Discharge) Trading Programs -- An Opportunity for Integrating Development Planning and Management," Proceedings of the International Conference on Impact Assessment in the Development Process: Advances in Integrating Environmental Assessment with Economic and Social Appraisal, University of Manchester, Manchester, England, October 23-24, 1998, pp

effluent trading, examples of ETP principles applied to the EIA process focused on surface water impacts, types of trades and their usage in the EIA process, and potential benefits from integrating development planning and cumulative effects assessments (CEAs) at project or strategic levels with ETPs.

FUNDAMENTALS OF EFFLUENT TRADING

To illustrate the concepts and technical needs associated with ETPs in the United States, Figure 10.1 depicts a watershed with applicable water quality standards (WQSs) for one to several pollutants, with the standards having been previously established based on designated beneficial uses of the water. The watershed has four point sources (PSs) of effluent discharge, with two being publicly owned treatment works (POTWs) and two being industrial wastewater treatment plants (Is). All four PSs are subject to effluent standards and National Pollutant Discharge Elimination System (NPDES) permit program requirements (NPDES is the permit system used in the United States). Figure 10.1 also identifies three areas designated as nonpoint sources (NPSs) of pollutant discharge, including runoff from agricultural land (NPS_a), forested land (NPS_f), and an urban area (NPS_u). In the United States, NPSs are not currently subject to runoff water quality regulatory controls.

For purposes of this illustration, it can be assumed that the river water quality in Figure 10.1 is not in compliance with one WQS. For example, if the phosphorus concentration is 3 mg/l and the standard is 1 mg/l, then the river water quality is not in compliance with the applicable standard. A situation such as this could result from the cumulative loading of phosphorus from PSs and NPSs. When this situation exists, the Clean Water Act (CWA) in the United States requires that the responsible state water management agency determine the total existing pollutant loading, and the Total Maximum Daily Load (TMDL) that the river can receive and still maintain the applicable WQS. The TMDL is sometimes referred to as the pollutant loading cap; however, the loading cap can also be set as a fraction of the TMDL in order to account for uncertainties. The total pollutant loading for each pollutant (PL_i) can be calculated as follows:

$$PL_i = \Sigma PS_i + \Sigma NPS_i + BG_i$$

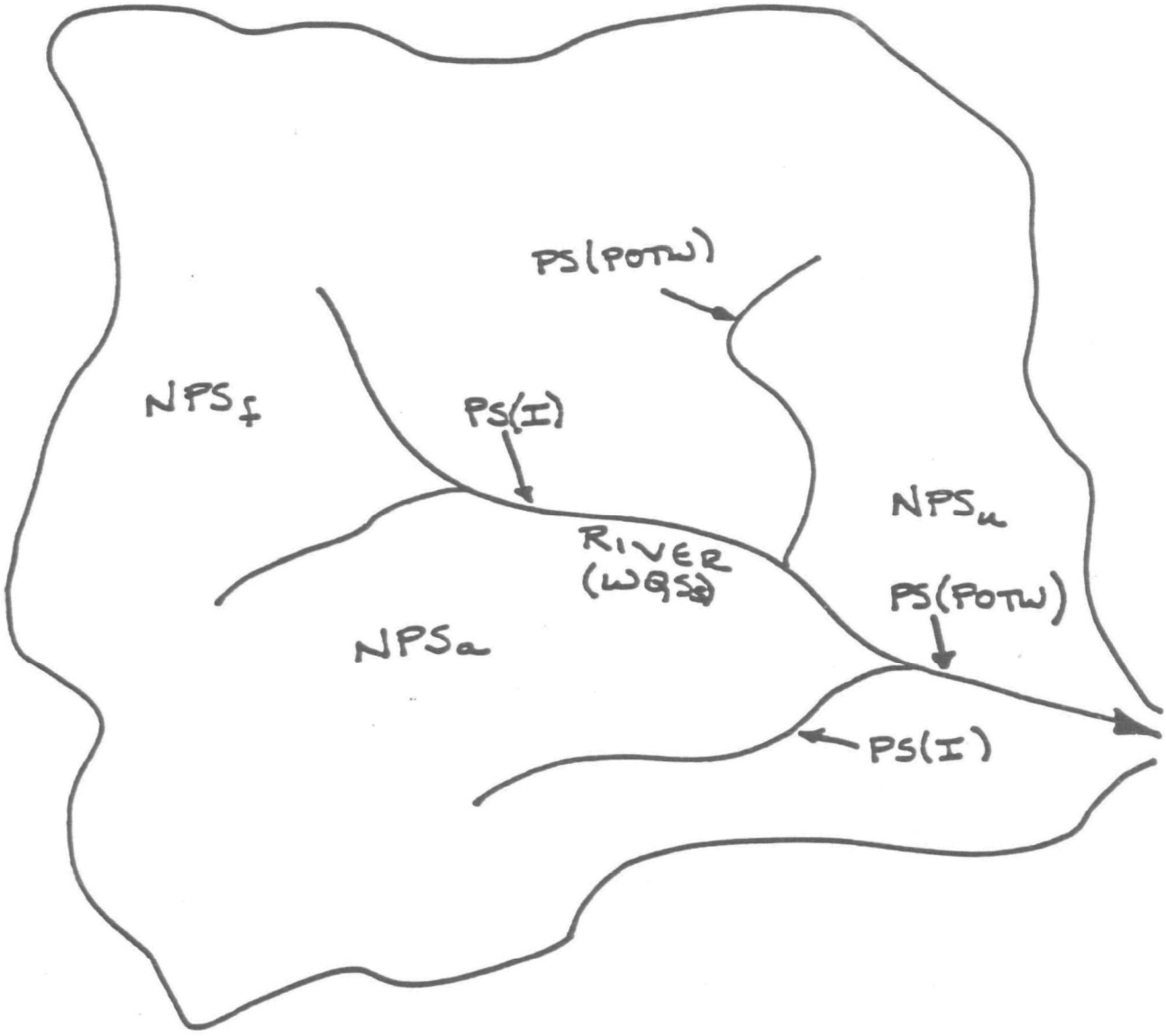
where

PS_i = contribution of the ith pollutant from each PS in the watershed

NPS_i = contribution of the ith pollutant from each NPS in the watershed

BG_i = contribution of the ith pollutant from natural background sources in the watershed

Approaches for quantifying the TMDL (or loading cap) for the ith pollutant include, but are not limited to, appropriate water quality modeling, proportioning the PL_i based on the ratio of the actual water quality to the WQS_i, or multiplying the range of expected river flows by the WQS_i to identify acceptable loadings for different flow conditions.



PS = point source; PS(I) = industrial point source; and PS(POTW) = publicly owned treatment works

NPS_f = nonpoint source from forested land; NPS_a = nonpoint source from agricultural land; and NPS_u = nonpoint source from an urban area

WQSs = water quality standards

Figure 10.1: Conceptual Aspects of an Effluent Trading Program in a Watershed

Once the TMDL is determined for the pollutant, the pertinent water management agency must then specify waste load allocations (WLAs) for each PS; and load allocations (LAs) for each NPS and background contributions. A "margin of safety" (MOS) load allocation could also be designated, based on a policy decision, to account for uncertainty in the analysis, future population growth and economic development in the watershed, and to provide a "safety factor." Expressed mathematically,

$$TMDL_i = \Sigma WLA_{PSi} + \Sigma LA_{NPSi} + LA_{BGi} + LA_{MOSi}$$

The WLAs and the LAs can be assigned based on water quality modeling results, proportioning of existing loadings, or the specification of effluent concentrations or required percentage removals for each source. It is typically assumed that no reductions are possible for natural background sources of the ith pollutant.

As a result of the above process, each PS may then be required to reduce their discharge of the ith pollutant to below the technology-based effluent standard as contained in the NPDES permit. In the United States, this is referred to as "a water quality-based effluent limitation" (WQBEL). For example, suppose the technology-based effluent standard for the ith pollutant for the POTW located in the upper watershed in Figure 10.1 is 5 mg/l, but the WLA and WQBEL requires a concentration of 2 mg/l. Further, NPSs may have specific LAs that are less than their current nonregulated discharges of the ith pollutant. For example, assume that the current loading of the ith pollutant from NPS_a is 10,000 lb/day; however, the TMDL and LA process has resulted in an assignment of 5,000 lb/day. Thus, the issue becomes focused on how each affected PS and NPS can comply with these requirements in a cost-effective manner. This is where an ETP might help.

To illustrate, if an ETP is established for the watershed in Figure 10.1, the upper watershed POTW could: (1) implement a higher level of treatment at more cost; (2) purchase existing pollution reduction credits (PRCs) from the lower watershed POTW, one or both of the industrial PSs, or NPS_f or NPS_u, if any of these sources have allocations which are greater than their current discharges; (3) "trade" some PRCs for the jth pollutant which exists in the effluent of the upper watershed POTW for PRCs for the ith pollutant from the lower watershed POTW, the two industrial PSs, or NPS_f or NPS_u (if such PRCs for the jth pollutant exist due to the allocation process and are needed by the other sources); (4) pay for additional treatment for the ith pollutant at any other PS or NPS in the watershed (if this treatment is less expensive; that is, if the marginal treatment costs are less than the marginal costs for additional treatment at the upper watershed POTW); (5) adopt pollution prevention measures in its service area; and/or (6) implement other measures such as appropriate water conservation. The upper watershed POTW could also consider combinations of these options in order to meet its WLA for the ith pollutant. Accordingly, it can be stated that the mitigation options have been expanded.

Regarding the options available for NPS_a, the state water management agency, perhaps in conjunction with the state agricultural agency, could encourage the adoption of best management practices (BMPs) to reduce the discharge of the ith pollutant from the agricultural area. Further, PRCs could be purchased from NPS_f or NPS_u, or, if economically justifiable, new or additional BMPs could be instituted at NPS_f or NPS_u. As a specific example, restoration or creation of wetlands which could retain (reduce)

the ith pollutant might also be considered. These examples also illustrate an expanded range of mitigation options.

EXAMPLES OF ETP PRINCIPLES APPLIED TO SURFACE WATER IMPACT STUDIES

A central issue basic to the success of an ETP is the existence of differences in the marginal costs of controls (the additional cost of controlling/removing an additional unit of the target pollutant) between affected sources. Accordingly, sources with high marginal costs in a trading area compensate those by "trades" with lower marginal cost sources to achieve more cost-effective solutions for pollutant loading reductions. Carefully planned trades should also address the present worth of equipment, construction, and operation and maintenance costs and the pollutant removal effectiveness of control strategies for involved sources. Further, because cost-effectiveness information is fundamental to the choices faced by the upper watershed POTW and NPS, and because market-based approaches to environmental management expand the available choices, it can be asserted that the fundamental objective of an ETP is to facilitate the cost-effective achievement of WQSs and related goals in a defined geographical area. However, ETPs should not provide loopholes or mechanisms for avoiding the technology-based requirements of the CWA. Accordingly, the U.S. Environmental Protection Agency has identified eight principles that ETPs must strive for in order to remain in compliance with the CWA and other laws and regulations, to demonstrate responsible environmental management, and to involve pertinent stakeholders in the process. These principles and their implications for ETPs are summarized in Table 10.1 (after U.S. Environmental Protection Agency, 1996).

Table 10.2 contains examples of how each of the 8 ETP principles are related to development project impact studies with an emphasis on changes in the surface water environment. Each of the listed principles have either direct or indirect applicability to the EIA process. The examples in Table 10.2 include identifying the characteristics of PS and NPS discharges, aggregating information on institutional requirements, describing the baseline water quality conditions, predicting and assessing the potential consequences, and using follow-up monitoring of discharges and receiving water quality. Public participation within the EIA process is also identified.

Careful examination of Table 10.2 reveals that there are no inherent incompatibilities between the principles of ETPs and their application to the EIA process. In fact, a symbiotic relationship exists between these two environmental management practices. Further, the existence or creation of an ETP can facilitate the incorporation of CEAs within project-level impact studies and strategic environmental assessments (SEAs).

TYPES OF TRADES AND USAGE IN THE EIA PROCESS

Based on the choices as delineated for the hypothetical example described above, as well as a survey of existing and planned ETPs, five types of trades have been identified. Table 10.3 summarizes definitions, several analyses, and related comments on each type. Careful review of Table 10.3 indicates that different affected sources may be more interested in certain types of trades. The affected sources could include existing or planned projects with wastewater or runoff discharges. For example, a PS(I) could conceivably explore the first four types, while a PS(POTW) could analyze pretreatment, point-point source, and point-nonpoint source trading. An affected NPS could consider the latter two types of trades.

Table 10.1: Fundamental Principles for Planning and Operating Effluent Trading Programs (after U.S. Environmental Protection Agency, 1996)

Principle	Implications for ETPs
Trading participants must meet applicable CWA technology-based requirements.	Preserves minimum levels of water quality protection mandated by the CWA. Promotes fairness by allowing only those sources which meet fundamental requirements to benefit from trading.
Trades should be consistent with water quality standards throughout a watershed, as well as the antibacksliding policy, and other requirements of the CWA, other federal laws, state laws, and local ordinances.	Ensures a certain level of water quality prior to implementation of a trading program. Promotes fairness by allowing only those sources which meet fundamental requirements to benefit from trading.
Trades are developed within a TMDL process or other equivalent analytical and management framework.	Allocates pollution control responsibilities among affected dischargers using a process that can be easily utilized to document trades. Data and analyses typically enable water quality managers to better understand and predict general effects of proposed trades.
Trades should occur in the context of current regulatory and enforcement mechanisms.	Trading partners must work with federal, state, tribal, and/or local regulatory authorities on a case-by-case basis to ensure an appropriate level of accountability and enforceability.
Trading boundaries generally coincide with a watershed or water body segment boundaries, and trading areas are of a manageable size.	Ensures that trading partners are affecting the same water body or stream/river segment, thus protecting against adverse local effects. Boundaries may vary for different pollutants. Boundaries may also be affected by the governing body or management structure of the trading program.
Trading will generally add to existing ambient monitoring.	Assessing the water quality impacts of trades may involve water quality analysis and modeling. The data needed depend on the sophistication of the analysis, the pollutant(s) involved, and the hydrodynamic and quality characteristics of the receiving water. In general, data on current water quality conditions, predicted effectiveness of pollution reduction options, and assessment of trading results are required.
Careful consideration should be given to the types of pollutants traded.	Analysis of trades, including the potential impacts of spatial or temporal variations in loadings, is necessary to avoid local violations in water quality standards. Careful consideration should be given as to whether cross-pollutant (interpollutant) trading could work under current regulatory conditions and technical limitations.
Stakeholder involvement and public participation must be key components of trading.	Educates stakeholder groups and the general public about the cost savings and environmental benefits of effluent trading. Educates ETP managers about the concerns of the general public. Builds new alliances within and between stakeholder groups and the general public, thus fostering better management approaches and more effective environmental protection.

Table 10.2: Relationships Between Fundamental Principles of ETPs and the EIA Process Focused on Surface Water Impacts

ETP Principle	Examples of Related Considerations in the EIA Process
Trading participants must meet applicable CWA technology-based requirements	Wastewater discharges from proposed development projects (PSs) must meet applicable CWA technology-based requirements; and the use of BMPs are encouraged for storm water runoff control from industrial activities and urban areas, and for other NPSs.
Trades should be consistent with water quality standards throughout a watershed, as well as the antibacksliding policy, and other requirements of the CWA, other federal laws, state laws, and local ordinances	Proposed development projects involving PSs and/or NPSs should also be in compliance and consistent with water quality standards in the watershed, as well as the antibacksliding policy, and other requirements of the CWA, other federal laws, state laws, and local ordinances. These compliance and consistency considerations can be used to determine the significance of predicted cumulative water quality impacts from proposed projects.
Trades are developed within a TMDL process or other equivalent analytical and management framework	The contribution of proposed development projects to the existing pollutant loading in the stream segment (or watershed) within the study area should be analyzed. Such analyses may also include mathematical modeling of cumulative water quality and aquatic ecosystem effects.
Trades should occur in the context of current regulatory and enforcement mechanisms	Proposed development projects are required to comply with appropriate statutory and regulatory requirements. Commitments to mitigation measures should be fulfilled. Enforcement activities can occur via the National Pollutant Discharge Elimination System (NPDES) permit program.
Trading boundaries generally coincide with a watershed or water body segment boundaries, and trading areas are of a manageable size	Spatial boundaries for impact studies need to be clearly defined. The scoping process can be used to facilitate the delineation of such boundaries. For surface water-related impacts, water body segments are often used; further, entire watersheds could be used depending on the type of proposed action. These types of considerations are also associated with CEAs focused on surface water quality.
Trading will generally add to existing ambient monitoring	Discharge monitoring may be required for proposed projects via the NPDES permit program. Follow-on monitoring of the resultant quality of the receiving body of water may be used in the case of large scale projects to facilitate effective environmental management. Monitoring of cumulative surface water quality effects can provide valuable information for future development planning.
Careful consideration should be given to the types of pollutants traded	Prediction and assessment of the water quality and aquatic ecosystem effects of proposed development projects is a fundamental component of the EIA process; such efforts should be focused on the types of pollutants associated with the proposed projects. Prediction and assessment should be accomplished within the context of considering the water quality impacts of past, present, and reasonably foreseeable future actions in conjunction with a specific proposed development project.
Stakeholder involvement and public participation must be key components of trading	Public participation within the EIA process can occur via scoping, the provision of opportunities within the project planning phase, and the review of prepared environmental impact statements (EISs). The types of publics should include various stakeholders associated with the proposed development project. Public participation is also important in CEAs.

Table 10.3: Types of Trades in ETPs

Type of Trade	Definition (after Podar, et al., 1996)
Intra-plant trading	A PS(I) uses its WLA as the basis upon which to allocate pollutant discharges among its outfalls in a cost-effective manner, provided that the combined permitted discharge with trading is not greater than the combined permitted discharge without trading.
Pretreatment trading	An industrial plant that provides pretreatment and then discharges to a POTW arranges, through the local control authority, for additional control by other local industrial plants beyond their minimum pretreatment requirements, in lieu of upgrading its own pretreatment for an equivalent level of reduction. Pretreatment trading could also be initiated by the local POTW which has been assigned a WLA.
Point-point source trading	A PS arranges for other PSs in a watershed to undertake greater than required control, or purchases available PRCs from such PSs, in lieu of upgrading its own treatment beyond the minimum technology-based requirements.
Point-nonpoint source trading	A PS arranges for control of one or more NPSs in a watershed in lieu of upgrading its own treatment beyond the minimum technology-based requirements. The NPS control arrangements could be direct or via payment by the PS to a specific control fund administered by a governmental agency.
Nonpoint-nonpoint source trading	A NPS arranges for more cost-effective control of other NPSs in a watershed in lieu of installing or upgrading its own control. The arrangements could be direct or via payment to a specific control fund administered by a governmental agency.

The following scenarios illustrate the potential application of the types of trades in Table 10.3 within the EIA process for development projects or plans, policies, and programs (SEAs):

(1) an existing industrial plant is to undergo a major renovation and expansion program, thus the use of intra-plant trading for the plant's PS discharges and storm water runoff could be explored within a project-level EIS; further, if the plant uses pretreatment prior to discharge to a POTW, pretreatment trading with other industrial dischargers could also be explored within the EIS;

(2) the impact study for a proposed new industrial complex (e.g., a petroleum refinery) could incorporate intra-plant trading for PS discharges to surface water, or pretreatment trading for discharges to a POTW;

(3) the impact study for a proposed POTW could include an analysis of point-point source trading, or point-nonpoint source trading, as alternatives to providing a higher level of treatment at the wastewater plant (these analyses could be included in the EIS);

(4) a proposed agricultural development plan could incorporate within the EIA process an analysis of nonpoint-nonpoint source trading as an alternative to less cost-effective BMPs; and

(5) a geographically-focused SEA should certainly refer to any ETPs which are completely or partially within the study area, and how they might influence or constrain development planning; further, if no ETPs are in existence, the SEA could serve to identify the need for one or more ETPs, and become a vehicle for the planning and implementation of such trading programs.

Regarding the current status of ETPs, a recent survey (June, 1998) is summarized in Table 10.4 (Canter, et al., 1998). A total of 26 programs have been identified, with 21 in the United States, three in Australia, and two in Canada (no programs have yet been identified in Europe). Twelve programs are existing, 10 are in the proposed stage, and four are undergoing a feasibility study. Nutrient trading is the basis for 15 programs (10 involve phosphorus, four both phosphorus and nitrogen, and one relates to nitrogen only). Three programs involve BOD trading, two each are related to selenium or salt (saline water), and one incorporates pollutants from the iron and steel industry. An additional three programs have not yet specified the tradeable pollutants. Regarding the types of trades, Table 10.4 indicates five singular types involving point-point, three involving point-nonpoint, two with nonpoint-nonpoint, and one each for pretreatment and intra-plant. Dual types of trades are allowed in six programs (five are point-point and point-nonpoint, and one is point-nonpoint and nonpoint-nonpoint). Eight of the listed programs have not yet specified the types of trades.

If development projects with potential project-induced and cumulative surface water impacts are under consideration within the trading areas of any of the ETPs listed in Table 10.4, the associated impact studies should obviously refer to the pertinent ETP. Table 10.5 summarizes six typical steps for addressing surface water impacts of proposed development projects, and the related requirements for an effluent trading study. Examination of Table 10.5 again reveals multiple symbiotic relationships between the EIA process, including CEA, and the

Table 10.4: Status of Effluent Trading Programs as of June, 1998 (after Canter, et al., 1998)

Program Title and Location	Program Status*	Tradeable Pollutant(s)	Types of Trades**
Bay of Quinte, Canada	F	Phosphorus	PS-PS PS-NPS
Bear Creek Watershed, Colorado	E	Phosphorus	PS-PS
Chatfield Reservoir, Colorado	E	Phosphorus	PS-PS, PS-NPS
Chemong Lake Watershed, Canada	F	Phosphorus	PS-NPS
Cherry Creek Reservoir, Colorado	E	Phosphorus	PS-PS, PS-NPS
Chesapeake Bay, Maryland (Note 1)	P	Nutrients	PS-PS, PS-NPS
Fox River, Wisconsin	E	BOD	PS-PS
Hunter River Salinity Trading Scheme, Australia	E	Saline water	PS-PS
Pretreatment Feasibility Study, Illinois	P		Pr
Iron and Steel Industry, Multiple States	E	Total suspended solids, oil and grease, lead, and zinc	In
Kalamazoo River Demonstration Project, Michigan	P	Phosphorus	PS-NPS
Lake Dillon, Colorado	E	Phosphorus	PS-NPS, NPS-NPS
Little Ausable Watershed, New York	P		
Long Island Sound, Connecticut and New York	P	Nitrogen	
Lower Boise River, Idaho	P	Phosphorus	PS-NPS
Minnesota River (Rahr Malting Company), Minnesota	E	CBOD	PS-NPS
Murray-Darling Basin, Australia	E	Salt	
Neuse River, North Carolina	P	Nutrients	PS-PS, PS-NPS

Table 10.4: (continued)

Program Title and Location	Program Status*	Tradeable Pollutant(s)	Types of Trades**
Pilot Phosphorus Offset Program, New York	E	Phosphorus	
Puyallup River, Washington	P	BOD, ammonia	
Regional Reserved Open Space Program, Virginia	P	Phosphorus	NPS-NPS
Rock River, Wisconsin	F(?)		
San Francisco Bay, California	P	Selenium	PS-PS
San Joaquin Valley, California	F	Selenium	NPS-NPS
South Creek Bubble License, Australia	E	Nutrients	PS-PS
Tar-Pamlico Basin, North Carolina	E	Nutrients	PS-PS, PS-NPS

* F = feasibility study; P = proposed effluent trading program; E = existing effluent trading program

** In = intra-plant trading; PS-PS = point source/point source trading; Pr = pretreatment trading; PS-NPS = point source/nonpoint source trading; NPS-NPS = nonpoint source/nonpoint source trading

Note 1: also known as Maryland Statewide Nutrient Trading Program

Shaded portions indicate that the information is not yet available.

Table 10.5: Relationships Between Typical Steps in a Surface Water-Focused Impact Study and Requirements for an Effluent Trading Study

Steps in Impact Study*	Related Requirements for Effluent Trading Study
Step 1 -- identification of the types and quantities of water pollutants to be introduced, water quantities to be withdrawn, and other impact-causing factors related to the development project	The types and quantities of tradeable water pollutants discharged by potential trading partners need to be determined. If water quantity trading is to be pursued, information will be needed on water usage by potential trading partners. The basis for the tradeable pollutants in terms of their water quality impacts in the trading program area should be included in the justification for establishing a trading program.
Step 2 -- description of the environmental setting in terms of river, lake, or estuarine flow patterns; water quality characteristics; existing or historical pollution problems; pertinent meteorological factors (examples are precipitation, evaporation, and temperature); relationships to area ground water resources; existing point and nonpoint sources of pollution; and pollutant loadings and existing water withdrawals	The environmental setting information noted in Step 2 should be a part of documented justification for the trading program; if such a program is to be implemented, this information will be necessary to provide the technical baseline. Extracts of this information could be used in analyzing potential trades.
Step 3 -- procurement of relevant laws, regulations, or criteria related to water quality and/or water usage, and any relevant compacts (agreements) between states, countries, or other entities related to relevant transnational waters	This information should already be a part of the basic documentation for an effluent trading program; if such a program is to be implemented, the statutory/regulatory information will be necessary for establishing statutory and institutional authority. Specific discharge (effluent) standards and related requirements such as WLAs or LAs for potential trading partners will be necessary for evaluating different types of trades.
Step 4 -- conduction of impact prediction activities, including the use of mass balances in terms of water quantity and/or pollutant-loading changes, mathematical models for relevant pollutant types (conservative, nonconservative, bacterial, nutrient, and thermal), aquatic ecosystem models to account for floral and faunal changes and nutrient-pollutant cycling, or qualitative predictions based on case studies and professional judgment	Proposed trades should be analyzed in terms of their effects on water quality. Tools which can be used include mass balances, mathematical modeling of water quality changes and aquatic ecosystem effects, and qualitative inferences based on related case studies and professional judgment. Water quality modeling of existing PSs and NPSs in the trading area should have been accomplished when the trading program was established.
Step 5 -- use of pertinent information from step 3, along with professional judgment and public input, to assess the significance of anticipated beneficial and detrimental impacts	Relevant statutory and regulatory requirements for the trading area should be used to evaluate the technical and public acceptability of proposed trades. Further, specific ETP rules related to trading ratios, monitoring and recordkeeping, reporting, and other matters can be used to evaluate proposed trades.
Step 6 -- identification, development, and incorporation of appropriate mitigation measures for the adverse impacts	The basic concept of an ETP is related to mitigating undesirable water quality impacts from existing or proposed PSs and NPSs in the trading area. The analysis of a proposed trade is focused on mitigating undesirable existing water quality problems in the trading area. The enforcement features of an ETP can be used to ensure that identified mitigation measures are actually implemented.

*after Canter (1996); these steps can be used for the direct and indirect effects of a proposed project, as well as for the cumulative effects of the project when considered in conjunction with past, present, and reasonably foreseeable future actions in a defined study area.

technical requirements for an effluent trading study. Further, information can be procured from an existing ETP irrespective of a trading study and used in several ways within the EIA process for a development project. For example, such information should be useful in: (1) describing the affected environment; (2) summarizing pertinent WQSs, regulations, and policies; (3) identifying water-related constraints to development; (4) predicting the water quality and quantity-related impacts of the project in relation to past, present, and reasonably foreseeable future actions via use of the modeling approaches incorporated within the TMDL process for the ETP; (5) assessing the significance of the predicted direct, indirect, and cumulative impacts; and (6) determining the trading opportunities which might be incorporated in impact mitigation measures for the project.

Step 4 in Table 10.5 includes water quality modeling, with this subject being a key technical component in the development of an ETP, as well as in the prediction of direct, indirect, and cumulative water quality impacts from development projects. Surface water quality and quantity models range from one dimensional steady-state models to three dimensional dynamic models which can be utilized for rivers, lakes, and estuarine systems (Henderson-Sellers, 1991; James, 1993; and U.S. Army Corps of Engineers, 1987). A recent book on surface water quality modeling addresses both modeling fundamentals and the use of mathematical models for simulating the transport and fate of pollutants in natural waters (Chapra, 1998). Models are described for different water environments (streams, estuaries, and lakes), water quality parameters (BOD, dissolved oxygen, nitrogen, phosphorus, bacteria, temperature, metals, and radionuclides), and water quality problems (sediment contamination and eutrophication). Depending upon the water environment and the specific needs basic to the ETP, and the characteristics of the development project, one to several of these models might be applicable.

A specific water quality model developed by the U.S. Environmental Protection Agency is called QUAL2E; this model can be used to examine the potential water quality impacts of flow changes and multiple pollutant releases in river systems. This sophisticated model accounts for advective and dispersive transport, and external or internal sources or sinks relative to specific pollutants. This model has been used in several ETPs and numerous impact studies for development projects. Information for downloading this model and other related water quality models can be obtained from EPA's Center for Exposure Assessment Modeling at the following Web site --http://www.epa.gov/CEAM/ceamhome.htm.

As noted above, water quality modeling is fundamental to the determination of TMDLs and pollutant loading caps, and the assignment of WLAs and LAs. Both procedural and modeling components for determining TMDLs are described elsewhere (U.S. Environmental Protection Agency, 1983a, 1983b, 1990, and 1991). Further, water quality modeling may need to be coupled with the use of geographic information systems (GISs). One reason is that the availability of source information, particularly as related to NPSs and background, may be less than uniform. To illustrate, the time variability of NPS loadings in a river system can vary widely as a function of the characteristics of the precipitation event, land usage, season, slope, soil type, and other factors (Byron, et al., 1998). Thus, a GIS can be a useful tool in relation to the identification of NPSs and their prioritization relative to necessary BMPs (Hall and Howett, 1996; and Fordiani, 1996).

BENEFITS FROM INTEGRATING DEVELOPMENT PLANNING WITH ETPs

In summary, when the EIA process is applied to development projects or strategic-level planning in a geographical area with an ETP, the potential benefits include, but are not limited to, the following:

(1) Information requirements can be extensive for planning and operating an ETP. Examples of such information include WQSs for the receiving water, water policies such as antidegradation and antibacksliding, a discharge permit program for PSs and associated records, water quality monitoring data for the receiving water and regulated PS discharges, and types of land uses in the study area. This information is necessary for developing pollutant loading information, TMDLs, loading caps, WLAs, and LAs. This information would be useable, as appropriate, in both project-level and strategic-level studies of direct, indirect, and cumulative effects.

(2) The ETP can be an encouragement for PSs associated with development projects to use "clean production technologies." Further, such new PSs will be encouraged to develop and implement pollution prevention and waste minimization measures.

(3) The results from ETP-required source and water quality monitoring can be used to evaluate the effectiveness of mitigation measures and trading relative to the development project, and to gain greater understanding of water resources and their quality management. Further, the ETP will expand the mitigation options available to both existing and proposed development projects. Finally, these results and "lessons learned" can be transferred to future development proposals.

(4) Cost savings for development projects in terms of water-related environmental management requirements. Further, monetary benefits could be realized by existing PSs (or NPSs) with available PRCs who participate in trading agreements with proposed development projects. These changes should provide an overall economic benefit to the study area.

(5) Development of pollutant loading information, TMDLs, loading caps, WLAs, and LAs in an ETP typically requires the use of several types of models. Further, the technical evaluation of proposed trades included within the EIA process may also include modeling of the anticipated water quality effects. These needs may "force" the adaptation or development of specific models for the trading area. Once the various models are operational, they can be used to evaluate cumulative water quality effects and management under different scenarios, including strategic-level planning involving the effects of population growth, economic development, and various management scenarios.

(6) An ETP encompasses a more holistic perspective regarding water quality management than does the traditional technology focus of command-and-control; this perspective should lead to more integrated and effective management strategies which can be included in cumulative effects emphases at the project-level as well as incorporated into strategic-level planning and SEAs. Integrated approaches will facilitate "environmentally sustainable development" practices in the trading area. In

the longer time frame, this may prevent water quality in the trading area from becoming a constraint to population growth and economic development.

SUMMARY

Market-based permit programs (emissions or discharge/effluent trading programs) are being utilized for air and water quality management at geographical scales ranging from the airshed/watershed to in-country regional, national, and even international dimensions. Such programs potentially offer more cost-effective approaches for environmental management than do traditional "command-and-control" approaches. Permit-related informational requirements for the characteristics of water pollutant discharges, the conditions of the receiving environment, effluent (discharge) trading and analyses of the environmental implications of the trades, are similar to such requirements in the traditional EIA process for development proposals with potential surface water impacts. In fact, mutual benefits can be realized by integrating marketable permit considerations within the EIA process. This chapter, which is based in part on a systematic review of ETPs in the United States, Canada, and Australia, explores the key principles of such programs in water quality management. Approaches for integrating these principles and related practices into the EIA process are then presented. Possible planning process and environmental benefits include the use of information from an ETP in the EIA process for a development project, possible cost savings for water quality management due to expanded mitigation options, and facilitation of cumulative effects assessments and "environmentally sustainable development" practices in the trading area.

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CHAPTER 11

MONITORING OF CUMULATIVE EFFECTS

The emphasis of this chapter is on the purposes (or uses) of cumulative effects monitoring in the environmental impact assessment (EIA) process, planning considerations for such monitoring programs, and brief descriptions of four examples. The primary thesis of this chapter is that a comprehensive (or targeted) monitoring program for cumulative effects should be required of major projects, plans, or programs as a part of their life cycle, and the resultant information should be used in environmentally responsible management and decision making.

Comprehensive environmental monitoring refers to the set of activities which provide chemical, physical, geological, biological, and other environmental, social, or health data required by environmental managers (U.S. Environmental Protection Agency, 1985). A targeted monitoring program could include elements related to environmental media (air, surface and/or ground water, soil, and noise), biological features (plants, animals, and habitats), visual resources, social impacts, and human health subjected to cumulative effects. Pertinent elements should be selected based on the project type, baseline environmental sensitivity, and expected cumulative effects. Components within the broad definition of environmental monitoring include: planning the collection of environmental data to meet specific objectives and cumulative effects information needs; designing monitoring systems and studies; selecting sampling sites; collecting and handling samples; laboratory analyses; reporting and storing the data; assuring the quality of the data; and analyzing, interpreting, and making the data available for use in decision-making (U.S. Environmental Protection Agency, 1985).

An integrating term being used in some countries to denote life-cycle environmental management, including the consideration of cumulative effects, is "post-project analysis" (PPA). PPAs refer to environmental monitoring studies undertaken during the implementation phase (prior to construction, during construction or operation and at the time of abandonment) of a given activity after the decision to proceed has been made (Economic Commission for Europe, 1990). Such studies can include comprehensive or targeted monitoring related to cumulative effects, evaluation of the collected data and information, environmentally focused decision-making as appropriate, and implementation of the management decisions. PPA could be viewed a continuous cycle over the life of a project, plan, or program. An example of such a monitoring program has been implemented to assess the cumulative effects of North Sea oil development on the Shetland Islands north of Scotland (Nelson and Butler, 1993).

Examples of environmentally responsible project management decisions which can be based on monitoring data, and which can be beneficial in terms of minimizing adverse cumulative effects and enhancing environmental management include: (1) reducing power production (and resultant atmospheric emissions) at a coal fired power plant in an industrial area with several stack emissions when atmospheric dispersion conditions are limiting; (2) planning multiple training activities at a military installation so as to not coincide with the use of certain training areas for breeding or nesting by threatened or endangered animal species; (3) planning and implementation of a metals removal system at an industrial

wastewater treatment plant so as to minimize metals uptake in aquatic food chains downstream of the wastewater discharge and other point and nonpoint sources of such metals; and (4) changing surface water reservoir water levels and water release patterns to optimize dissolved oxygen concentrations in the water phase during various seasons, particularly when the reservoir is subjected to multiple point and nonpoint sources of organic pollution.

PURPOSES OF CUMULATIVE EFFECTS MONITORING

Numerous purposes (and implied benefits) can be delineated for pre- and/or post-EIS (environmental impact statement) cumulative effects monitoring. For example, Marcus (1979) identified the following six purposes or uses of information from the conduction of post-EIS monitoring (the wording of the purposes has been modified to focus on cumulative effects):

(1) Provides information for documentation of the cumulative effects that result from a proposed action when considered in conjunction with other past, present, and future actions, with this information enabling the more accurate prediction of cumulative effects associated with similar actions.

(2) The monitoring system could warn agencies of unanticipated adverse cumulative effects or sudden changes in effects trends.

(3) The monitoring system could provide an immediate warning whenever a pre-selected indicator of cumulative effects approaches a pre-selected critical descriptive or numerical level.

(4) Provides information which could be used by agencies to control the timing, location, and level of the cumulative effects resulting from a proposed project. Control measures would require preliminary planning as well as the possible implementation of regulation and enforcement measures by several governmental agencies. If an intergovernmental monitoring program is used it could facilitate appropriate response measures by multiple agencies.

(5) Provides information which could be used for evaluating the effectiveness of implemented mitigation measures for identified cumulative effects.

(6) Provides information which could be used to verify predicted cumulative effects and thus validate prediction techniques. Based on these findings the techniques; e.g., mathematical models, could be modified or adjusted as appropriate.

The Council on Environmental Quality (CEQ) regulations in the United States primarily require monitoring, including cumulative effects monitoring, in conjunction with the implementation of mitigation measures. Mitigation includes avoiding the cumulative effect altogether by not taking a certain action or parts of an action; minimizing cumulative effects by limiting the degree or magnitude of the action and its implementation; rectifying the cumulative effect by repairing, rehabilitating, or restoring the affected environment; reducing or eliminating the cumulative effect over time by preservation and maintenance operations during the life of the action; and/or compensating

for the cumulative effect by replacing or providing substitute resources or environments (after Council on Environmental Quality, 1978).

Sadler and Davies (1988) describe three types of environmental monitoring which might be associated with the life cycle of a project. These include monitoring of existing conditions, effects or impact monitoring, and compliance monitoring. Monitoring of existing conditions is the measurement of environmental variables during a representative pre-project period to determine existing characteristics, ranges of variation, and processes of change. Effects or impact monitoring involves the measurement of environmental variables during project construction and operation to determine changes which may have been caused by the project. Finally, compliance monitoring takes the form of periodic sampling and/or continuous measurement of levels of waste discharge, noise, or similar emission, to ensure that conditions are observed and standards are met. Pre-EIS monitoring includes baseline monitoring, while post-EIS monitoring encompasses effects or impact monitoring, and/or compliance monitoring. While these three types of monitoring are not specific to cumulative effects, it would be easy to focus them on this topic.

As suggested by Sadler and Davies (1988), monitoring can serve as a basic component of a periodic environmental regulatory auditing program for a project (Allison, 1988). In this context, auditing can be defined as a systematic, documented, periodic and objective review by regulated entities of facility operations and practices related to meeting environmental requirements (U.S. Environmental Protection Agency, 1986). Some purposes of environmental auditing are to verify compliance with environmental requirements; evaluate the effectiveness of in-place, environmental management systems; and/or assess risks from regulated and unregulated substances and practices. Some direct results of an auditing program include an increased environmental awareness by project employees, early detection and correction of problems and thus avoidance of environmental agency enforcement actions, and improved management control of environmental programs (Allison, 1988). Cumulative effects monitoring could be incorporated into a regulatory auditing program.

To serve as a final example, a multicountry task force on EIA auditing conducted a comparative analysis of 11 case studies in order to document environmental monitoring practices (Economic Commission for Europe, 1990). The reviewed monitoring programs were primarily related to the direct and indirect effects of specific proposed actions. The purposes for conducting such monitoring as delineated in the case studies included (Economic Commission for Europe, 1990): to monitor compliance with the agreed conditions set out in construction permits and operating licenses; to review predicted environmental impacts for proper management of risks and uncertainties; to modify the activity or develop mitigation measures in case of unpredicted harmful effects on the environment; to determine the accuracy of past impact predictions and the effectiveness of mitigation measures in order to transfer this experience to future activities of the same type; to review the effectiveness of environmental management for the activity; and to use the monitoring results in order to determine the compensation required to be paid to local citizens affected by a project. Although these identified purposes were not unique to cumulative effects, they could be easily modified to focus on such effects.

In summary, the primary point to note from the above examples of different monitoring purposes is that such purposes can be wide ranging; therefore, monitoring purposes for cumulative effects need to be incorporated in the planning and implementation of a monitoring effort for a project/plan/or program.

PLANNING FOR CUMULATIVE EFFECTS MONITORING

Detailed planning for a cumulative effects monitoring program can include many considerations; examples of such considerations are related to delineating monitoring objectives, selecting sampling locations and parameters to be measured, utilizing appropriate analytical procedures, storing and retrieving data, interpretation of the collected information, preparation of written reports, and implementing certain follow-on measures based on the monitoring results. To illustrate, Table 11.1 summarizes a list of eight such considerations (fundamental components or planning elements) for planning and implementing a program (after Marcus, 1979). It should be noted that iterations within and between elements may be necessary during both the planning and implementation of a program. Over time, the eight elements in Table 11.1 have been sharpened in focus via the identification of related or additional concepts such as: (1) provision of feedback from the program to the EIA process; (2) adaptation in the program; (3) use of testable hypotheses for effects predictions; (4) clear delineations of temporal and spatial scales; (5) use of consistent documentation; and (6) provision of public participation opportunities.

CASE STUDIES RELATED TO CUMULATIVE EFFECTS MONITORING

This section briefly summarizes four examples of cumulative effects monitoring as incorporated within the EIA process. The examples include operation of the reservoir system on the Tennessee River and the Elk Creek Lake in Oregon (USA), the Niagara Escarpment Plan area in southern Ontario (Canada), and timber harvesting in Washington and Oregon (USA). A more detailed review of the latter example is provided.

Reservoir System on the Tennessee River

A comprehensive illustration of environmental monitoring, including cumulative effects monitoring, coupled with on-going decision-making, was associated with the operation of the 16 extant reservoirs and dams in the Tennessee River system (Tennessee Valley Authority, 1991). The monitoring program included measurements of river flows, water quality (dissolved oxygen and other constituents), and the effectiveness of aeration of water releases from the dams. The purpose of this program was to determine the influence of reservoir operational patterns on water quality (particularly dissolved oxygen), and to improve water quality and aquatic habitat by increasing minimum flow rates and aerating releases from the TVA (Tennessee Valley Authority) dams to raise dissolved oxygen levels, and to extend the recreation season on TVA lakes by delaying drawdown for other reservoir operating purposes, primarily hydropower generation.

Elk Creek Lake in Oregon

The Elk Creek Lake project is a concrete dam and reservoir to be located on Elk Creek, approximately 1.7 miles upstream from its confluence with the Rogue River in Oregon. The project was authorized by the U.S. Congress in 1962 as one of three dams in the Rogue Basin Project. Project purposes include flood control, irrigation, water supply, and recreation (U.S. Army Corps of Engineers, 1991). A targeted pre- and post-EIS environmental monitoring program was described in the final EIS Supplement No. 2 for the Elk Creek Lake project. A portion of this monitoring effort was attributable to the decision of the Federal Ninth Circuit Court of Appeals in the case of Oregon Natural Resources Council v. Marsh. The Ninth Circuit ruled in this case that the EIS and EIS Supplement No. 1 for

Table 11.1: Examples of Elements in a Cumulative Effects Monitoring Program (after Marcus, 1979)

Element	Tasks Associated with Element
(1) Identify and define major cumulative effects	•Identify cumulative effects for consideration for monitoring on the basis of their significance as described in the EIS.
(2) Coordinate with governmental agencies already conducting monitoring in the area, or who would be interested in monitoring, or have responsibilities related thereto.	•Contact all agencies having pertinent monitoring responsibilities in area to be affected. •Identify agencies' major areas of environmental concern. Determine for what aspects of the environment and for what type of cumulative effects the agencies are responsible. •Identify individual agency basis of authority to control cumulative effects through decisionmaking, planning, regulation, monitoring, and enforcement.
(3) Define monitoring objectives.	•Define monitoring objectives in terms of major potential cumulative effects and in terms of agency authority. •The objectives should be specified as to whether they relate to establishing baseline conditions, conducting effects monitoring, or to implementing compliance monitoring relative to mitigation or environmental requirements.
(4) Determine data requirements for achieving monitoring objectives.	•Reevaluate cumulative effects identified for monitoring (element 1) on the basis of monitoring objectives; eliminate overlap in monitoring objectives and monitoring effort. •Select cumulative effects indicators (these are the parameters that must be monitored to assess the magnitudes of effects). Several parameters may be indicative of a particular effect. Cumulative effects indicators should be selected on the basis of their utility for decisionmaking, planning, regulation, and enforcement. •Determine frequency and timing of data collection. Frequency of data collection should be the minimum necessary for trend analysis, enforcement of regulations, and correlation of cause and effects. Timing of data collection should relate to the timing of activities causing the cumulative effect. •Determine monitoring sites or collection areas. These should be based on the location of the activities causing the cumulative effects, predictions of areas most likely to be affected, and locations where integrated measurements would assist in gaining comprehensive understanding. •Determine method of data collection. Data can be collected in several ways; for example, vegetative-cover data can be collected by field collection methods or by remote-sensing techniques. Determine analytical requirements, as appropriate, for the collected samples. •Determine data storage and retrieval requirements and necessary formats.

Table 11.1 (continued):

(5) Develop implementation plan, including budgetary requirements and individuals/groups/or agencies responsible for various elements.	• Determine budgetary, personnel, and time requirements for obtaining data. • Determine whether proposed monitoring system is feasible within budgetary, personnel, and time constraints. If program has to be reduced, several potential approaches are available for reducing the monitoring system to a feasible level: the scope of monitoring objectives can be reduced; alternative cumulative effects indicators can be selected; the frequency of data collection can be reduced; and alternative methods of data collection can be used.
(6) Collect and analyze the monitoring data (and project operational data; if appropriate) in view of the identified monitoring objectives (element 3).	• Identify baseline condition or effects trends; identify rate of change. (The rate at which an cumulative effect is increasing may be significant because of the need to respond to effects trends in a timely fashion before critical effect levels are reached). • Identify cumulative effects that have reached critical levels. (Critical effects levels requiring immediate notification of participants should be set for each effect being monitored.) Identify effects that have exceeded legal limits. • Evaluate effectiveness of mitigating measures, as appropriate.
(7) Implement project management activities, as appropriate, to manage/mitigate undesirable cumulative effects.	• Plan responses to cumulative effects trends. Responses to unacceptable effects can be directed at the activity causing the effect or at the effect itself. • Respond to critical effect levels: stop or modify activities causing effect; treat effect. • Respond to evaluations of mitigation measures by revising, terminating, or adding measures as appropriate.
(8) Prepare periodic monitoring reports.	• Prepare reports at regular time intervals to document the monitoring program, key environmental trends, and response actions.

the Elk Creek Lake project did not fully comply with the requirements of the National Environmental Policy Act (NEPA). Subsequent review of the case by the U.S. Supreme Court reversed in part the decision of the Ninth Circuit Court. As directed by the order of the U.S. District Court, EIS Supplement No. 2 was prepared to comply with the opinions of the U.S. Supreme Court, the Ninth Circuit Court of Appeals, and the U.S. District Court for the District of Oregon (U.S. Army Corps of Engineers, 1991). Monitoring for several water quality, fisheries, and terrestrial habitat parameters was conducted at two existing reservoirs and dams (Applegate Dam and Lost Creek Dam) and at the proposed site for Elk Creek Dam in the Rogue River Basin. More specifically, monitoring was conducted for water temperature, turbidity, and suspended sediment; river flow rates; game fish; and terrestrial habitats for eight evaluation species.

Water quality and terrestrial habitat modeling was used for analyzing single project and cumulative effects related to the Elk Creek Lake project. Water quality models used for evaluating temperature, turbidity, and suspended sediment impacts included the Water Resources Engineers, Inc. model (WRE), two Corps of Engineers models (the WESTEX model and the CE-THERM-R1 model), and a U.S. Environmental Protection Agency model (QUAL II). Four physical parameters (land cover, soils, slope, and stream network) were monitored in a remote sensing/GIS (geographic information system) analysis of suspended sediment/turbidity. Fisheries resources studies for salmon and steelhead populations assessed changes in emergence timing of fry from river gravel; the abundance of juvenile fish, their size, growth rate and migration timing; and the abundance, migration timing, pre-spawning mortality, and spawning of adult fish. Eight terrestrial species in the Rogue River Basin were studied through usage of the Habitat Evaluation Procedures of the U.S. Fish and Wildlife Service (U.S. Army Corps of Engineers, 1991). Because of the extensive cumulative effects modeling, one of the purposes of the monitoring program was to validate extant water quality models, and also to serve as a basis for future predictions of both single project and cumulative effects on fisheries, water quality, and terrestrial wildlife habitat.

Niagara Escarpment Plan Area in Southern Ontario

A monitoring program for the Niagara Escarpment Plan area in southern Ontario in Canada has been proposed (Rennick, 1994). The area is a designated United Nations Biosphere Reserve, and monitoring in this context is defined as the repetitive measurement of indicators which will enable a better understanding of spatial and temporal changes in environmental quality. The following generic steps were utilized in developing the Niagara monitoring program (Rennick, 1994):

(1) establish management goals;

(2) identify the ecological (natural, social, cultural) units for the monitoring program;

(3) develop a monitoring framework;

(4) select indicators and parameters or targets to be measured;

(5) decide on sampling frequency, locations, etc.;

(6) select measures which can be used to determine the significance of data collected (e.g., environmental standards and guidelines);

(7) collect the data;

(8) manage and interpret the data; and

(9) report and use the information to assess and modify goals and objectives, environmental management practices and the monitoring system itself.

Timber Harvesting in Washington and Oregon

To explore the application of monitoring and related monitoring planning elements in EIA practice, Canter and Harrington (1997) described a systematic review of the monitoring programs included in 9 EISs. The monitoring program in one EIS was primarily related to the cumulative effects of management of habitat for late-successional and old-growth forest related species within the range of the endangered northern spotted owl in western portions of Washington and Oregon, and the northwestern portion of California. Examined within the EIS were proposed actions consisting of combinations of: (1) land allocations managed to protect and enhance habitat for late-successional and old-growth forest related species and to protect and enhance aquatic resources; and (2) standards and guidelines for the management of these land allocations (U.S. Bureau of Land Management and U.S. Forest Service, 1994).

An original EIS related to timber harvesting in areas that also provided habitat for the northern spotted owl was highly controversial. The fundamental reason was the conflict between timber harvesting interests and the need in the Pacific Northwest and Northern California for maintaining forest habitat for the endangered northern spotted owl and other species. Timber harvesting would not only supply consumer demand for wood products, but also support the local economy in the region through timbering contracts and timber sales. The importance of fulfilling both development and conservation needs came to the forefront in April, 1993, when President Clinton sponsored a Forest Conference in Portland, Oregon. The Conference was attended by various concerned organizations and citizen groups.

After the Conference, a Forest Ecosystem Management Assessment Team (FEMAT) was assembled and charged with the responsibility of developing an impact study that took an ecosystem approach to forestry management. The results were organized into a Supplemental EIS by the U.S. Bureau of Land Management and the U.S. Forest Service, along with the U.S. Department of Agriculture. The described monitoring program focused on potential impacts to aquatic ecosystems, air quality, water quality, soil productivity, threatened and endangered species, nonvascular plants and allies, vascular plants, invertebrates, vertebrates, timber harvest yields, regional employment, rural communities, and American Indian peoples and cultures (U.S. Bureau of Land Management and U.S. Forest Service, 1994).

Although no specific laws were mentioned as being the impetus for requiring the implementation of a monitoring program, several laws were referred to in the Supplemental EIS as having a potential role in affecting the proposed action. The relevant laws or regulations that played a part in the included monitoring program were NEPA, the CEQ regulations, the Endangered Species Act, Clean Water Act, Clean Air Act, and Forest Management Act.

The monitoring program section of the Supplemental EIS was presented in great depth. The section began with a statement that the rationale for monitoring was to "detect changes in ecological systems from both

individual and cumulative management actions and natural events and to provide a basis for natural resource policy decisions" (U.S. Bureau of Land Management and U.S. Forest Service, 1994). A discussion was then provided as to what types of monitoring would be conducted. Implementation, effectiveness, and validation monitoring were the types explicitly mentioned. In addition, it was implied that baseline and effects monitoring, including cumulative effects, were to be performed.

The monitoring program was also focused on both short-term and long-term effects of the proposed actions. The program included specific reference to monitoring potential cumulative effects on environmental resources. Ecosystem monitoring as well as individual resource monitoring was to be performed. The monitoring activities were not limited to physical observations; they included complex quantifiable hypotheses testing. In fact, specific reference to formulating the monitoring activities for the testing of various hypotheses of impact predictions was included.

Identification of who would conduct the monitoring activities was also provided. The agency or agencies responsible for the proposed action will be the parties that conduct monitoring. The proponents addressed potential claims of biased monitoring results by stipulating that local interdisciplinary teams (third parties) will review the monitoring data. Also, the proponents stated that other governmental agencies wanting to review the results may also do so.

In the monitoring program description, funding was implied as being provided in an annual U.S. Forest Service budget. A clear statement regarding the actual amount allocated for monitoring in such an annual budget, and cost estimations for specific monitoring activities, were the only items missing. It was apparent that monitoring was considered a high priority of the proponents by the statement that "monitoring... (should) be carefully and reasonably designed" (U.S. Bureau of Land Management and U.S. Forest Service, 1994).

need "a priori" decis — to establish response

The proponents described how this monitoring program would reflect the utilization of adaptive management principles. According to the Supplemental EIS, adaptive management "is a continuing process of action-based planning, monitoring, researching, evaluating and adjusting with the objective of improving the implementation and achieving the goals of the selected alternative," and it "acknowledges the need to manage resources under circumstances that contain varying degrees of uncertainty, and the need to adjust to new information" (U.S. Bureau of Land Management and U.S. Forest Service, 1994). Therefore, a feedback loop was provided into the on-going decision-making process for the purpose of adjusting to improve implementation of the plan, while ultimately hoping to achieve the objectives of regulatory standards and guidelines.

SUMMARY

A comprehensive or targeted cumulative effects monitoring program should include usage of extant monitoring data and coordination with pertinent governmental monitoring systems. Program planning and implementation should include the delineation of objectives related to expected key cumulative effects, selection of pertinent indicators (variables) and determination of sampling location and frequency and analytical requirements, the pre-development of response strategies (management actions) and periodic reporting.

Based upon the systematic review of the described monitoring programs in the 9 EISs (including the program for the northern spotted

owl), Canter and Harrington (1997) have recommended that the following 12 elements be included in planning and describing cumulative effects monitoring programs within the EIA process:

(1) identification of cumulative effects to be monitored;

(2) a definition of monitoring to encompass the planned program;

(3) specification of related laws and/or regulations;

(4) description of related extant monitoring programs being conducted by other agencies or entities;

(5) delineation of the specific objectives of the program in terms of establishing existing conditions, conducting cumulative effects monitoring for the short term and long term, and/or compliance monitoring (note that some objectives could be stated in an hypothesis format, particularly as related to cumulative effects monitoring);

(6) technical details related to what will be monitored, when monitoring will take place, and where it will occur (inferred here is the need for defining temporal and spatial scales for the program);

(7) attention to special issues such as ecosystem monitoring and the possible use of adaptive environmental management;

(8) implementation procedures for collection and evaluation of data according to standard protocols, and who will be responsible for monitoring (in-house staff and/or third party groups);

(9) provisions for the use of data via feedback into EIA decisionmaking processes (adaptive management principles could be utilized);

(10) specifications for reporting frequency and distribution of reports;

(11) provisions for public participation opportunities within the overall cumulative effects monitoring program; and

(12) inclusion of budgetary requirements and actual or potential sources of funding.

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CHAPTER 12

MITIGATION OF CUMULATIVE EFFECTS -- BIODIVERSITY AND ECOSYSTEM MANAGEMENT CONSIDERATIONS

The focus of cumulative effects considerations within the environmental impact assessment (EIA) process has been related to possible changes in resources (e.g., air or water quality or trout fisheries) or ecosystems. Because of the larger spatial and temporal scales typically associated with cumulative effects, broader environmental issues may need to be addressed. Two such issues are biodiversity and ecosystem management. These two issues can be considered from the perspective of mitigation planning for undesirable cumulative effects on resources and ecosystems. This chapter explores the fundamental aspects of biodiversity and ecosystem management regarding potential mitigation considerations for cumulative effects. In so doing, it should be recognized that mitigation for cumulative effects will tend to become more focused on these broader issues.

BACKGROUND ON BIODIVERSITY

Biological resources are important from ecological, economic, and aesthetic perspectives. Ecological importance is derived from the provision of ecological services, such as regulation of hydrologic cycles, carbon and nutrient cycling, soil fertility, support of commercially and recreationally important fish and wildlife populations; and from aesthetic, ethical, and cultural values associated with unique forms of life. The diversity of species and genetic strains provides critically important resources for potential use in agriculture, medicine, and industry. Sustainable usage of these resources provide economic value to both current and future generations (Council on Environmental Quality, 1993). Aesthetic value is derived via recreational activities, including visits to "natural areas" in order to experience undisturbed locations.

An important indicator of the ecological, economic, and aesthetic value of biological resources is biological diversity. Biological diversity (or biodiversity) has been defined as the variety of species, the genetic composition of species and communities, ecosystems and ecological structures, and the variety of functions and processes at all levels (Canadian Environmental Assessment Agency, 1996). A related definition is that biological diversity (biodiversity) is the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (Canadian Environmental Assessment Agency, 1996). Table 12.1 summarizes some of the components of biological diversity (Council on Environmental Quality, 1993).

Recognition of the importance of biological diversity was included in the National Environmental Policy Act (NEPA); specifically, item (4) in Section 101 states that it shall be a national policy 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." Thus biodiversity considerations could be incorporated in both project-level impact studies and strategic environmental assessments (SEAs).

Table 12.1: Components of Biological Diversity (Council on Environmental Quality, 1993)

- 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.

Of particular concern in relation to the EIA process are the potential detrimental effects on biodiversity which can occur from individual to multiple development activities. Some examples of development projects which are likely to induce significant impacts on biodiversity are listed in Table 12.2 (World Bank, 1997). Further, application of the EIA process at strategic levels to generate SEAs will also necessitate consideration of biodiversity impacts. In fact, it could be argued that biodiversity impact considerations are more important in SEAs than in project-level EIAs due to the larger geographical areas and longer time frames typically associated with SEAs. This same argument can be made for project-level EIAs which include cumulative effects assessments (CEAs).

In late 1991 and 1992 the Council on Environmental Quality (CEQ) in the United States, in conjunction with several other federal agencies, conducted a series of conferences designed to explore the need for improved incorporation of concerns for ecosystem integrity and the protection of biological diversity into the decision-making process under NEPA (Council on Environmental Quality, 1993). A number of factors were identified which have or are contributing to the decline of biodiversity in the United States. Such decline can be seen in the loss of ecosystems, wetlands, and habitat for threatened or endangered animal species. These losses have typically been associated with the cumulative effects of multiple projects in a defined geographical area. Factors contributing to the decline of biodiversity include physical alterations due to resource exploitation and changing land usage; pollution; overharvesting; introduction of exotic (non-native) species and elimination of native species through predation, competition, genetic modification, and disease transmission; disruption of natural processes; and global climate change (Council on Environmental Quality, 1993).

Because of mankind's influence on the global decline of biodiversity, in the Rio de Janeiro conference on environment and development held in 1992, the United Nations initiated a Convention on Biological Diversity. The Convention is a legally binding international treaty which obliges signatory countries to assess the adequacy of current efforts to conserve biodiversity and to use biological resources in a sustainable manner (Canadian Environmental Assessment Agency, 1996). Further, Article 14 of the Convention recognizes the EIA process as an important decision-making process for the protection of biological diversity. Additional information on the Convention on Biological Diversity is available elsewhere (Krattiger, et al., 1994).

Biodiversity considerations can be important in environmental management. The basic goal of biodiversity conservation is to maintain naturally occurring ecosystems, communities, and native species. Conservation of existing biodiversity is a basic principle of environmentally sustainable development (United Nations Environment Program, 1996). The basic goals when considering biodiversity in management are to identify and locate activities in less sensitive areas, to minimize impacts where possible, and to restore lost diversity where practical (Council on Environmental Quality, 1993). Certain principles (not rules) can be enumerated for incorporating consideration of biodiversity into environmental management, including the EIA process with associated cumulative effects considerations; these principles include (Council on Environmental Quality, 1993):

(1) take a "big picture" or ecosystem view;

(2) protect communities and ecosystems;

Table 12.2: Examples of Development Projects Which Are Likely to Induce Significant Impacts on Biodiversity (World Bank, 1997)

- Agriculture and livestock projects involving land clearance, wetlands elimination, water diversion and inundation for storage reservoirs, displacement of wildlife by domestic livestock, use of pesticides, or planting of monoculture crop systems.
- Fisheries/aquaculture projects involving conversion of important natural migration, breeding or nursery sites, over-fishing, or introduction of exotic species.
- Forestry projects that involve clear-felling, or other forms of intensive forest harvesting or conversion of natural habitats, construction of access roads, or establishment of forest products industries which may induce development.
- Transportation projects involving construction of highways, bridges, rural roads, railways, airports, or canals that penetrate natural habitats and ecosystems and open them to colonization and immigration; also, channelization of rivers for navigation and dredging and coastal land reclamation for ports.
- Power projects involving (1) hydroelectric development that inundates or transforms natural habitats and ecosystems, alterations of rivers because of dams or water diversions, and construction of power transmission corridors through undisturbed natural areas; and (2) projects that depend upon fossil fuels from which airborne pollution may threaten or destroy vegetation or from which heated effluents may elevate the temperature of receiving waters.
- Oil and gas projects involving land clearance, pipeline construction, coastal storage, transfer and handling facilities, or offshore activities.
- Industrial development involving thermal pollution from cooling water discharges or chemical pollution of aquatic and terrestrial environments via air or water.
- Large-scale loss of natural habitat to mining and mineral exploration.
- Urban and tourism development in sensitive areas such as coastal zones.

(3) minimize fragmentation, promote the natural pattern and connectivity of habitats;

(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; and

(11) monitor for biodiversity impacts, acknowledge uncertainty, and be flexible.

BIODIVERSITY AND THE EIA PROCESS

The importance of addressing biodiversity within the EIA process has been recognized by many countries. For example, in addition to developed countries such as the United States, Canada, and Australia, this subject has also been recognized in Indonesia (Dahuri, 1994), Malaysia (Leong, 1994), and Thailand (Bunpapong, 1994). Several Canadian case studies on the incorporation of biodiversity considerations in the EIA process are available (Doran, et al., 1998). In New South Wales in Australia, the EIA process has been linked to programs focused on the conservation of biodiversity (Stone and Little, 1998). Further, international organizations such as the United Nations Environment Program and the World Bank have responded to the need for addressing biodiversity within the EIA process (United Nations Environment Program, 1996; World Bank, 1995; and World Bank, 1997). However, it should be recognized that such biodiversity considerations have primarily related to project-level EIA.

Process and Methods

The Council on Environmental Quality (1993) has suggested that agencies can incorporate biodiversity considerations in the EIA process in the following key ways:

(1) during the scoping process, the proponent agency should determine whether the proposed action may affect biodiversity via direct, indirect, or cumulative means;

(2) during the analysis of impacts, the proponent agency should determine the potential direct, indirect, and cumulative impacts on biodiversity of the proposed action and each of the alternatives;

(3) during mitigation planning, the proponent agency should identify appropriate mitigation measures in response to the potential direct, indirect, and/or cumulative impacts on biodiversity; and

(4) planning and implementation of targeted monitoring programs to document the experienced biodiversity impacts during project

operation, including cumulative impacts, and the effectiveness of the implemented mitigation measures.

It has been suggested that the consideration of biodiversity issues in the EIA process represents an extension of current practice associated with assessing ecological impacts. Some key topics to be addressed in this extension (some of which may have been addressed in ecological impact considerations) include (United Nations Environment Program, 1996): (1) taxonomic diversity - the range of micro-organisms and plant and animal species in an ecosystem or area; (2) genetic diversity - the range of genetic characteristics found in a population or species; (3) ecosystem diversity - the range of interacting natural systems (for example, lake/wetlands and forest/lake) present within a region, landscape or the biosphere; (4) ecosystem functions - the interactions provided by species and ecosystems with other species, and the relationship between local species and systems and global support systems; and (5) the abiotic matrix - effects on the non-living portion of the soil, water, atmosphere and biophysical processes which support species and ecosystems. Addressing these topics requires a broader view of the spatial and temporal boundaries of a study, with such a view being a necessity in CEA.

The Canadian Environmental Assessment Agency (1996) suggested the following biodiversity-related questions (modified to focus on cumulative effects) which EIA practitioners should consider during the scoping phase of an impact study:

(1) What species, communities and ecological processes would be impacted by the project (either directly, indirectly, or cumulatively)? Are any of these species endangered, endemic, sustainably used, new to science, or special in some other way?

(2) How much habitat would be eliminated or degraded as a result of cumulative effects, including short-term use areas vital to seasonal, life-history or migratory cycles?

(3) Are critical thresholds or levels of capacity being reached, i.e., are the species already in severe decline?

(4) What values does society attribute to each species, community and ecological process?

(5) Could any migratory species be affected in another portion of their range and thus cumulatively affect the species/population?

(6) What time, spatial, or other issues need to be considered for each of the species, communities and ecological processes affected directly, indirectly, or cumulatively by the project?

(7) Do major systemic or population changes appear to be taking place as a result of past development and/or management practices?

(8) What historical trends or cumulative losses of species and habitat are involved?

Methods which can aid in the identification of cumulative effects on biodiversity prior to initiation of the scoping process include checklists, matrices, network diagrams, and overlay-mapping via the use of geographic information systems (World Bank, 1997). Further information on

these methods is in Chapter 5 herein and in Canter (1996). Literature reviews of biodiversity impacts organized by project type can also be helpful. Such reviews can be used to identify the cumulative effects of multiple types of projects in a geographical area.

Current information will be needed on existing biodiversity conditions in the geographical area to be included in an impact study. The first consideration should be to assemble extant information. One key information source in the United States is the natural heritage network; it is summarized in Table 12.3 (Council on Environmental Quality, 1993). Contacts with federal and state environmental and natural resources agencies should also yield useful information. In fact, broader scale ecological studies are now being conducted. These types of studies would be particularly useful in addressing cumulative effects. For example, the U.S. Environmental Protection Agency has conducted an ecological assessment of the mid-Atlantic region (encompassing Delaware, the District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia) (Jones, et al., 1997). To illustrate the type of included information which could be used in either project-level EIAs or SEAs, following are some of the major findings (Jones, et al., 1997):

(1) The mid-Atlantic region has diverse spatial patterns of agriculture and urban lands as compared to other parts of the country (about 10% of the nation's watersheds have been almost completely converted to agricultural land, while about 40% of the nation's watersheds have only small amounts of agriculture, excluding livestock grazing). Mountainous watersheds in the mid-Atlantic region have the least amount of agricultural and urban land cover and coastal areas the greatest.

(2) Mid-Atlantic region watersheds have relatively high (more desirable) values for forests, forest connectivity, and forests near streams (riparian zones) as compared to other parts of the country, especially the Midwest and southwestern United States.

(3) Six watersheds in the south-central portion of the region along the border with North Carolina, ten watersheds in the southwestern portion of the region, and three watersheds in north-central Pennsylvania have the most desirable landscape conditions based on the suite of landscape indicators. These areas have relatively low values for population, road density, and agriculture, and have the highest amounts of forest and riparian vegetation.

(4) Nineteen watersheds in the northwestern, northeastern and Norfolk, Virginia areas of the region have the least desirable landscape conditions. These watersheds have high values for population density, road density, agriculture on steep slopes, and sulfate deposition, and low values for riparian vegetation and interior forest indicators. These areas are typically around the major metropolitan areas of Baltimore-Washington, D.C., Pittsburgh, and Norfolk.

(5) The remaining watersheds fall between the most desirable and least desirable conditions. Some appear to be in a desirable condition relative to one environmental theme, but in a less-desirable condition relative to another. For example, watersheds in the Delmarva Peninsula are in better relative condition from a water quality perspective, but provide little interior forest habitat. Conversely, several watersheds

Table 12.3: The Natural Heritage Network (Council on Environmental Quality, 1993)

State Natural Heritage Data Centers have been established in all fifty states as cooperative ventures of The Nature Conservancy (TNC) and various state agencies. Satellite data centers operate in several staffed preserves, including two National Parks, and in various offices of cooperating state and federal agencies and private institutions. A number of federal agencies, including DOD and the U.S. Forest Service, have agreements with TNC to collect and manage data through the Heritage Network.

Heritage data centers focus on natural community types and individual species. The idea is that major natural communities will act as a "coarse filter" to capture populations of the majority of species, including invertebrates and other small organisms too numerous to inventory individually, while focus on populations of known rare species will act as a "fine filter" for these uncommon elements.

All Heritage programs also amass and organize data on land ownership, existing preserves and protected areas, secondary information sources (including publications, repositories, individual experts, institutions), and key individual contacts (key data users, agency personnel, mailing lists).

A large degree of standardization of terminology, methods, formats, and systems has been achieved and maintained among the many Heritage programs. This facilitates the exchange of information, efficient methodological research and technical support, consistent communication with users, and the combination of information from many programs.

Fundamental information available in this system includes the following:

Species:

Each Heritage data center tries to maintain information on all the vascular plants and vertebrate animal species in its state or area of coverage along with information on a limited number of invertebrates and non-vascular plants believed to be particularly rare or otherwise of conservation interest. A systematic ranking process is employed to ascertain the relative degree of biological endangerment of each species included, and this is documented in element ranking records. Each species is ranked as to its status on a global and state basis using consistent criteria of rarity (the estimated number of occurrences of each element) and threat (vulnerability to human disturbance or destruction). Using this system, the highest priority would be given to species with a ranking indicating threats at both global and state levels. Rankings consist of a letter – G for global and S for state – and a number – with 1 indicating the highest threat level. A G1S1 ranking would indicate that the species or community is critically imperilled both globally and regionally (typically five or fewer occurrences or extremely vulnerable to extinction due to biological factors). Originally, Heritage programs only dealt with rare species, but it was gradually found desirable to include at least limited amounts of information on all vertebrates and vascular plants. However, for efficiency's sake, total inventory effort is still allocated among species in proportion to their relative endangerment.

Communities and Ecosystems:

Each state Heritage data center develops a taxonomic classification of natural community types known within its geographic area. In places where there is a well-developed local tradition of community classification, the local system is adopted as a beginning point and modified as knowledge and perspective accumulate. In other places, a new classification is developed. Efforts are now underway to ensure regional and national consistency among these efforts. Heritage data centers attempt to include occurrences of all community types. Communities are ranked according to a set of criteria similar to the species ranking system.

Other Biological Information:

Other types of biological information can include anything that merits inventory and conservation planning, such as areas of seasonal wildlife concentration, breeding colonies of common species, outstanding individuals (such as champion trees), and areas of historical field work.

Managed (or Protected) Areas:

All State Heritage programs gather and organize information on all protected and semi-protected areas in their states, regardless of ownership. This information can provide a comprehensive picture of protected natural land and habitat for each state.

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throughout the Ridge-and-Valley and Appalachian Plateau areas have the opposite pattern, with relatively more interior forest habitat but less-desirable conditions for water-related indicators (such as the amount of crop land on steep slopes).

In many cases the availability of current biodiversity information may be inadequate. Accordingly, field studies may be necessary. Examples of field methods/techniques which can be used for describing existing biodiversity conditions in an impact study are listed in Table 12.4 (World Bank, 1997). Conduction of such field studies would only be expected for large-scale development proposals where cumulative effects are a concern. In most impact studies incorporating CEA, it would be expected that existing biodiversity information would be utilized.

Cumulative effects prediction for biodiversity may involve calculations related to changes in habitat size, changes in habitat quality or biodiversity indices, and/or the use of sophisticated ecosystem models. Qualitative predictions can be made based on the review of existing conditions and the application of professional judgment. Additional information on biophysical impact prediction is in Canter (1996).

The significance of predicted cumulative effects on biodiversity should be described relative to the local, regional, national, and international context, as appropriate. Such significance determinations must be based on the professional judgment of qualified biodiversity specialists. Some biodiversity-related questions which could be considered by EIA practitioners and biodiversity specialists when analyzing the potential direct, indirect, or cumulative effects of a proposed action include (Canadian Environmental Assessment Agency, 1996):

(1) What impact (direct, indirect, or cumulative) will the proposed action (project) have on the genetic composition of each species? Are different genotypes of the same species likely to be isolated from each other? To what extent will habitat or populations be fragmented?

(2) How will the project cumulatively affect ecosystem processes? Is this proposal likely to make the ecosystem more vulnerable or susceptible to change?

(3) What abiotic effects will devolve - changes in seasonal flows, temperature regime, soil loss, turbidity, nutrients, oxygen balance, etc?

(4) Does the project and related cumulative effects contribute to or undermine the sustainable use of biological resources?

(5) Does it set a precedent for conversion to a more intensive level of use of the area?

(6) Is diversity measured at the species, community and ecosystem level?

(7) Have exotics been included in measures of diversity?

(8) Have standardized protocols for diversity measurement been applied when available?

(9) Is the biological resource in question at the limit of its range?

Table 12.4: Examples of Field Methods/Techniques Useful for Determining Baseline Conditions for Biodiversity (World Bank, 1997)

Ecosystem/habitat level	
Targets	**Methods/Techniques**
• Distribution, richness and diversity of habitats and ecosystems	• Field surveys (transects/quadrants) and inventories, maps of fauna and flora
• Patchiness, connectivity/fragmentation of habitat(s)/ecosystem(s); corridors; fragile habitats and ecosystems	• Remote sensing, landuse maps, field surveys
• Carrying capacity and community dynamics	• Measurement of standing crop/biomass or productivity
Population/species level	
Targets	**Methods/Techniques**
• Population structure and dynamics, including harvesting pressure(s), abundance/composition of key species	• Inventories, field surveys, demographic analysis; use of biological indicators and indices (species sensitive to changing conditions)
• Existence of endemic, rare, vulnerable, and/or endangered species	• Inventories, field surveys

(10) Does the species demonstrate adaptability?

(11) Have sustainable yield calculations, including population dynamic parameters, been determined (e.g., lake capacities, population thresholds)?

(12) Is the data dependable? What are the sources used?

(13) Is the assessment based on long-term ecological monitoring, baseline surveys, reconnaissance level field observations, and primary research?

(14) Is sampling planned on a suitably spaced geographic grid pattern (two-dimensional for land, three-dimensional for lakes and oceans, etc.)?

(15) Does the sampling cover more than one or two years to assess annual variations and all the seasons studied?

The following guiding principles (or goals) have also been suggested for use in assessing the effects of a proposed action on biodiversity (Canadian Environmental Assessment Agency, 1996):

(1) minimum impact on biological diversity;

(2) no "net loss" of the ecosystem, species populations or genetic diversity;

(3) application of the precautionary principle to avoid irreversible losses (the precautionary principle is used where an activity raises threats or harm to the environment or human health, and precautionary measures taken even if certain cause and effect relationships are not established scientifically);

(4) no effect on the sustainable use of biological resources;

(5) maintenance of natural processes and adequate areas of different landscapes for wild flora and fauna and other wild organisms;

(6) use inferential information, e.g., identify species that are rare or at the limit of their range and therefore a possible early warning of critical ecological change;

(7) where possible, use indicator species or valued ecosystem components to focus the assessment;

(8) define the spatial parameters that characterize ecological processes and components in order to provide a regional context for an analysis of the direct, indirect, and cumulative effects of the proposed project;

(9) identify the best practicable option (mitigation) for maintaining biological diversity; and

(10) examine the cumulative effects of other activities in the area/region to date and evaluate the added "effect" that this project, and others likely to follow, will have on biological diversity.

Finally, it should be noted that the assessment (or interpretation) of information on levels of biodiversity in specific geographical areas can be problematic. Accordingly, Spellerberg (1998) has suggested a conceptual framework for the development of "standards" for biological diversity. However, the adoption of numerical standards, or even qualitative (descriptive) standards, is not expected to occur for some time.

Following the identification, prediction, and assessment of biodiversity impacts, it may be necessary to identify and implement appropriate mitigation measures. Examples of mitigation measures for adverse biodiversity impacts include, but are not limited to, the following (World Bank, 1997): (1) site protection through project redesign; (2) strategic habitat retention; (3) restricted conversion or modification; (4) reintroduction of species; (5) post-development restoration works; (6) restoration of degraded habitats; and (7) establishment and maintenance of an ecologically similar protected area of suitable size and contiguity. The appropriateness of one or combinations of these measures would be dependent on the project being analyzed and the cumulative effects concerns.

The importance of public involvement in conserving biological diversity is also well-recognized, especially for situations where conservation involves imposing restrictions upon the use of lands enjoyed by the public or considered the domain of indigenous peoples (World Bank, 1997). Accordingly, public involvement should begin in scoping and continue through the identification of pertinent mitigation measures.

Concerns and Obstacles

Biodiversity considerations should be incorporated in environmental quality planning and in the EIA process (also called the National Environmental Policy Act process, or the NEPA process in the United States). However, there are concerns associated with such incorporation in relation to current EIA practice, and three illustrations will be mentioned. Examples of some current weaknesses in the NEPA process in the United States in relation to biodiversity include the following (Council on Environmental Quality, 1993):

(1) Inadequate consideration of "non-listed" species. Agencies should address the requirements of the Endangered Species Act in EISs (environmental impact statements) and EAs (environmental assessments). Certainly, impacts to threatened and endangered species directly affect biodiversity. However, only about 600 U.S. species are officially listed as threatened or endangered, while estimates indicate that as many as 9,000 species may currently be at risk. Reliance on listed threatened and endangered species is likely to address only a small portion of the nation's imperiled biodiversity.

(2) Inadequate consideration of "non-protected" areas. While NEPA documents may give adequate recognition to direct, indirect, or cumulative impacts on areas that have been set aside as parks or refuges, or are already identified as meriting special protection (e.g., wetlands), they often do not consider areas that have not been so designated, but that are equally important to biodiversity.

(3) Inadequate consideration of "non-economically important" species. The potential effects on species of recreational and commercial importance are often considered. However, some

practices intended to maximize protection or production of these species conflict with wider biodiversity objectives. For example, the impoundment of salt marshes to create waterfowl habitat can reduce estuarine biodiversity. The stocking of rainbow trout for sport and commercial fisheries has resulted in the replacement of wild brook trout in Appalachian streams, and the endangerment of native squawfish, chubs, and suckers in the Colorado River system. The creation of forest openings and edge habitat favoring game species is now recognized as causing severe impacts to interior forest-dwelling species.

(4) Inadequate consideration of cumulative impacts. Finally, and perhaps most importantly, the majority of EISs and EAs deal only with project-specific considerations. If effects on biodiversity are to be adequately assessed, it must be done on an ecosystem or regional scale, taking into account cumulative effects. Avoidance or mitigation of impacts at the project level (such as redesigning a highway to avoid damaging a sensitive bog, or modifying a coal lease to protect a raptor nesting area) has been, and will continue to be, critically important in minimizing biodiversity losses. Yet, in the absence of protection at the larger scale, ecosystem patterns and processes so important to biodiversity will not be sustained over the long term.

To serve as a second illustration, the World Bank (1997) has indicated that the following mistakes or oversights are occurring relative to biodiversity in Bank-sponsored impact studies: (1) inadequate determination of the spatial context of the project; (2) poor or insufficient existing information and treatment of biodiversity as simple "lists" of species found in a project area; (3) lack of rigor in the analysis of costs/benefits; and (4) insufficient attention to implementation and monitoring of mitigation measures and environmental management plans, including institutional arrangements. Each of these mistakes/oversights are relevant for direct, indirect, and cumulative-effects.

Finally, the following obstacles to the effective incorporation of biodiversity considerations in the EIA process in the United States have been identified (Council on Environmental Quality, 1993): (1) lack of recognition of the importance of biodiversity; (2) lack of information on local and regional ecosystem diversity; (3) lack of awareness of available information; (4) incomplete understanding of biodiversity conservation and its relationship to ecosystem management; (5) mismatches between agency jurisdictions, boundaries and ecosystem boundaries; (6) institutional conflicts within and among agencies; and (7) the absence of cohesive regional ecosystem plans and strategies. These obstacles are also relevant for direct, indirect, and cumulative effects.

Recommendations for Improvement

NEPA provides a mandate and a framework for federal agencies in the United States to consider all reasonably foreseeable environmental effects of their actions. To the extent that federal actions affect biodiversity, and that it is possible to both anticipate and evaluate those effects, NEPA requires federal agencies to do so. Accordingly, and despite the obstacles listed above, the CEQ has developed six recommendations for agency-driven improvements in the consideration of biodiversity in NEPA analyses, these recommendations and associated comments are in Table 12.5 (Council on Environmental Quality, 1993). Adherence to these

Table 12.5: Recommendations for Agency Improvements Related to Biodiversity Considerations in the NEPA Process (Council on Environmental Quality, 1993)

	Recommendation	Comments
1.	Acknowledge the conservation of biodiversity as national policy and incorporate its consideration in the NEPA process.	Agencies should insure that both staff responsible for conducting environmental impact analyses and decision-makers responsible for considering the findings of those analyses are familiar with the importance of the biodiversity issue and its relevance to their work. Agency-sponsored environmental training courses should discuss biodiversity and how best to consider it in the NEPA process and in all planning, design, and management.
2.	Encourage and seek out opportunities to participate in efforts to develop regional ecosystem plans.	Regional ecosystem frameworks are a critical element of conserving biological diversity. Such regional efforts can provide an ecosystem framework for evaluating the impacts of individual projects on biodiversity, and provide a common basis for describing the affected environment. Both will save time and financial resources in preparing NEPA documents. Agencies should investigate and consider participation in efforts that may be already in progress in areas where they have jurisdiction or interest. Some regional frameworks exist that do not explicitly address biodiversity. In such cases, agencies should consider establishing specific goals and objectives for the conservation of biodiversity, within those frameworks. Finally, where such efforts are lacking entirely, agencies should consider initiating them.
3.	Actively seek relevant information from sources both within and outside government agencies.	While information on the status and distribution of biota is incomplete, a great deal of information is available from a wide variety of sources. Agencies should look to each other, to state agencies, and to academic and other non-governmental entities. By doing so, agencies can benefit from the resources and technical capabilities of others and reduce the costs associated with collecting and managing information on which ecosystem and biodiversity analyses depend.
4.	Encourage and participate in efforts to improve communication, cooperation, and collaboration between and among governmental and non-governmental entities.	Improved communication, cooperation, and collaboration will enormously improve the prospects for overcoming the barriers described earlier. Working with others can help to identify common interests and overlapping or complementary missions, and can lead to mutual sharing of information, technical capabilities, and expertise. Efforts to do so will require support at the management and policy-making levels within agencies, as well as at the level of the staff responsible for carrying out NEPA analyses.
5.	Improve the availability of information on the status and distribution of biodiversity, and on techniques for managing and restoring it.	Agencies that support or sponsor research and development efforts that will improve our ability to evaluate and manage for biodiversity should ensure that the information they obtain is maintained in a format that is useful and is readily accessible. Agencies should consider opportunities to cooperate with and benefit from the National Biodiversity Center, presently in the planning and design stages. A key role of the Center will be to identify existing ecological information and make it more readily available for use in environmental planning and assessment.
6.	Expand the information base on which biodiversity analyses and management decisions are based.	Basic research is needed into a host of issues relating to both ecosystem management and biodiversity conservation. These include ecosystem functioning; selection of indicators; prediction of the effects of change on ecosystems; and establishment of spatial and temporal boundaries for impacts and analyses. Agencies should recognize the research opportunities afforded by projects, and consider sponsoring or cooperating with academic institutions, private industry, and others on research to advance ecological understanding.

recommendations would enhance the consideration of cumulative effects on biodiversity within the EIA process.

BACKGROUND ON ECOSYSTEM MANAGEMENT

Ecosystem (ecological) management includes the analysis of both the elements and the interrelationships involved in maintaining ecological integrity (Council on Environmental Quality, 1993). Such management should use a local-to-regional perspective that considers impacts at the appropriate scale within the context of the entire ecosystem. These considerations are particularly important when exploring mitigation opportunities for cumulative effects. One aspect of ecosystem management involves attention to the conservation of biological diversity. A science-based book on ecosystem management is now available. The book, which includes 11 chapters written by 18 experts, addresses fundamental concepts and their applications (Woodley, Francis, and Kay, 1994).

The federal government in the United States is encouraging the implementation of ecosystem management approaches within and between federal agencies and between federal, state, and local agencies. Such agency collaboration is typically necessary when addressing mitigation considerations in relation to cumulative effects. To facilitate the implementation, the Interagency Ecosystem Management Task Force was formed by the federal government in the mid-1990s. The work of this Task Force and other entities and individuals has been instrumental in defining the following general principles for ecological management (Keiter and Adler, 1998):

(1) Common ecological management goals should be socially defined through a collaborative vision process that involves all interested participants and that incorporates ecological, economic, and social considerations.

(2) Given that most ecosystems and watersheds, as well as cumulative effects, transcend conventional geopolitical boundaries, ecological management requires coordination among federal, state, tribal, and local governmental entities as well as collaboration with other interested parties.

(3) Ecological management policies and decisions should be based upon integrated and comprehensive scientific information that addresses multiple rather than single resources.

(4) Ecological management seeks to maintain and restore biodiversity and ecosystem integrity.

(5) Ecological management involves management at large spatial and temporal scales that correspond to ecosystems and watersheds; such scales are typically required when including CEA within the EIA process.

(6) Given the finite nature of public funds and other resources, ecological management enables agencies to engage in careful targeting to select achievable solutions and to allocate resources efficiently.

(7) Ecological management requires an iterative, adaptive management approach to account for changing goals and values and new scientific information concerning ecological conditions. In fact, because of scientific uncertainties related to cumulative effects on ecosystems, monitoring and

adaptation of management practices represent a desirable approach.

Management of land resources, ecosystems, and watersheds over a large geographical area for long periods of time is required in comprehensive ecological management (Keither and Adler, 1998). Stakhiv (1996) has identified four institutional reasons for using the watershed as the basic scale for organizing such ecological management programs; they are: (1) the proliferation of disparate regulatory agency programs that protect various aspects of water-dependent public health and environmental quality concerns; (2) the increased emphasis by all federal resources management agencies on improving ecosystem management and restoration through their respective programs and authorities; (3) budgetary constraints which are forcing greater cooperation and complementarity among federal programs; and (4) the watershed scale, rather than the large river basin scale, makes comprehensive planning efforts more tractable. An additional reason is that the watershed represents a potentially convenient geographical scale for organizing cumulative effects information.

Examples of Ecosystem Management

Examples of ecosystem management case studies are described by Sommers and Lackey (1997). The case studies include: (1) the Interior Columbia River Basin Ecosystem Management Project by the U.S. Forest Service and the U.S. Bureau of Land Management (the Basin is in the Pacific Northwest region); (2) the Southern Appalachian Assessment within a region encompassing parts of seven states; (3) five watershed assessments incorporating the ecological risk assessment process (the five watersheds included Big Darby Creek in central Ohio, Clinch River Valley in southwest Virginia, Middle Platte River in south central Nebraska, Middle Snake River in south central Idaho, and Waquoit Bay on the southern shore of Cape Cod in Massachusetts); and (4) several illustrations from the U.S. Department of Defense (included are examples from Camp Pendleton, California; the Chesapeake Bay Program; the Mojave Desert Ecosystem Initiative; and Eglin Air Force Base, Florida). Each of these examples are related to mitigation planning in response to recognition of the undesirable consequences of cumulative effects from development projects or plans.

Ecosystem management has also been addressed by the General Accounting Office (GAO) in two review reports (U.S. General Accounting Office, 1994a and 1994b). One GAO study relates to ecosystem management opportunities for four federal agencies -- the National Park Service, the Bureau of Land Management (BLM), and the Fish and Wildlife Service (FWS) within the Department of the Interior and the Forest Service within the Department of Agriculture (U.S. General Accounting Office, 1994a). The relationship between the cumulative effects of military training activities and ecosystem management is addressed in the other GAO study (U.S. General Accounting Office, 1994b). The six facilities which were addressed include: (1) Fort Greely Maneuver Area and Air Drop Zone and (2) Fort Wainwright's Yukon Maneuver Area, both in Alaska; (3) Goldwater Air Force Range in Arizona; (4) Nellis Air Force Range and (5) Bravo-20 Bombing Range, both in Nevada; and (6) McGregor Range in New Mexico.

Ecosystem management perspectives also need to be incorporated into federal agency permitting processes, particularly when the permit review reveals cumulative effects issues. For example, implications related to the permitting of mining operations in the western United States have been addressed by McDonald and Martin (1995). Permitting for grazing actions

should also include the consideration of ecosystem management opportunities.

The U.S. Army Corps of Engineers has also been engaged in a number of ecological restoration projects in the 1990s. Such projects are being done to mitigate cumulative effects on specific ecological resources. As such, a prototype has been developed for plan formulation and cost estimation for such environmental restoration projects (Scodari, et al., 1995). Environmental restoration provides unique opportunities for monitoring the effectiveness of restoration measures relative to the management of ecosystems.

To illustrate the scientific and institutional uncertainties in ecosystem management, a case study involving ecological restoration for cumulative effects on the sockeye salmon will be described. The location is in the Columbia River Basin in the northwestern United States; the Basin, which includes the Snake River, has federally owned hydroelectric dams operated and maintained by the U.S. Army Corps of Engineers and the Bureau of Reclamation of the U.S. Department of the Interior. The Bonneville Power Administration is responsible for transmitting and marketing the hydroelectric power generated by these dams. The Corps has eight dams on the lower Columbia and Snake Rivers which serve as a major source of hydroelectric power and also provide flood control, navigation, recreation, irrigation, municipal and industrial water supply, and fish and wildlife benefits. However, the dams impede juvenile and adult fish migrations to and from the ocean (U.S. General Accounting Office, 1998).

In 1991, the National Marine Fisheries Service (NMFS) listed the Snake River sockeye salmon as an endangered species, and in 1992, the Snake River spring/summer and fall chinook salmon were listed as threatened. Biological opinions were then issued by the NMFS regarding operation of the hydropower system. Included in the opinions were mitigation actions for the Corps' eight dams. Examples of immediate and intermediate mitigation actions included (U.S. General Accounting Office, 1998): (1) augmenting river flows to help juvenile salmon migrate downstream, thus requiring releases of water from upstream storage reservoirs during the spring and summer juvenile salmon migration; (2) spilling river flows at the dams rather than passing them through hydropower turbines where juvenile salmon experience higher mortality rates; (3) collecting juvenile salmon at certain dams and transporting them downstream by barge or truck, past remaining dams, where they are released back into the Columbia River; (4) developing a gas abatement program, including appropriate structural modifications, to reduce gas supersaturation; (5) designing and constructing facilities at John Day and Bonneville Dams to improve sampling and monitoring of juvenile salmon as they migrate past these dams; and (6) relocating the outfall structure from which juvenile salmon exit the bypass facility at Bonneville Dam to reduce mortality caused by predator fish.

In response to the NMFS' biological opinion, the Corps has worked cooperatively with all interested parties, including federal and state agencies and Native American tribes, in implementing its fish mitigation actions. The cooperative efforts have been facilitated via a Regional Forum of stakeholders who review and evaluate specific mitigation proposals and annual programs.

Through October, 1997, the Corps had initiated 47 of the 58 mitigation actions contained in the overall program (U.S. General Accounting Office, 1998). A total of 28 of the 47 actions have been, or are expected to be, completed on time and within budget. However, 19 larger actions (8 studies and 11 projects) have been delayed, or have encountered cost increases, or both. Several scientific and institutional

factors have caused the delays or cost increases. Examples include (U.S. General Accounting Office, 1998): (1) changes in fish mitigation priorities; (2) effects of adverse weather on project implementation; (3) contractors' performance problems; (4) revisions in the scope of projects; and (5) bid protests.

In summary, this case study illustrates that both scientific and institutional uncertainties can influence ecological restoration (ecosystem management) efforts conducted in response to cumulative effects. Scientific information is basic to designating species as endangered or threatened. Further, such information needs to be used in identifying and designing mitigation measures. Institutional problems can arise from conflicting objectives on the part of multiple stakeholders, needs to satisfy a variety of regulatory requirements and related permits, and inadequate funding to accomplish all restoration measures. Further, monitoring of the effectiveness of the measures should be done in an on-going manner, with the results used for adaptive management of the mitigation program.

Finally, seven examples of ecosystem management partnerships and their work to date to mitigate cumulative effects are available (Interagency Ecosystem Management Task Force, 1996). The examples include: (1) Anacostia River watershed-- state and local agencies are restoring components of this system of marshes, rivers, and forests in urban environments; (2) Coastal Louisiana -- a federal task force and the state of Louisiana are restoring wetlands to reverse the trend of losses; (3) Great Lakes basin -- local communities joined with governmental agencies to reverse water pollution and aquatic habitat degradation; (4) Pacific Northwest forests -- an interagency effort is focused on protecting both forest ecosystems and the region's economic health; (5) Prince William Sound -- a state/federal trustee council is restoring the ecosystem following the Exxon Valdez oil spill; (6) South Florida -- a federal task force is working to restore habitat in the Everglades; and (7) Southern Appalachians -- the Man and Biosphere program is working with local cities and towns to restore habitats.

Ecosystem Management -- Illustrations from the U.S. Army

The U.S. Army manages hundreds of thousands of acres of U.S. lands in conjunction with multiple projects and activities associated with military training and with the provision of recreational opportunities at civil works project sites. Military bases and civil works projects are located throughout the different ecoregions (ecosystems) of the U.S. Due to the extensive lands associated with specific Army bases, and the fact that adjacent land use pressures may be excessive, military installations may be likened to "islands of refuge" for numerous wildlife species. In addition, military training lands are typically subject to a wide variety of activities, with these activities creating undesirable cumulative effects which differ in their nature and extent. Examples of military training activities which may occur either singly or in combination at given installations include: (1) conduction of military training exercises; (2) firing of artillery and missiles; and (3) training to operate military vehicles such as tanks.

Even though land usage may be extensive at military and civil works facilities, the majority of the lands are used only periodically, if at all. Nonusage areas could include buffer zones between the facilities and adjacent private land uses, or between specific facility activities. In addition, the U.S. Army is still responsible for the management of land at many abandoned bases while land is still government owned. Therefore, the opportunity exists for the U.S. Army to develop and implement effective

Table 12.7: Topical Outline for an Integrated Natural Resources Management Plan for a U.S. Army Installation (after Williamson, 1997)

- Executive Summary

- Chapter 1 -- Goals and Policies

  1.1 Goals
  1.2 Policies
  1.3 Monitoring Progress (annual basis)

- Chapter 2 -- Location and Acreage

  2.1 Location
  2.2 Acreage and Acquisition
  2.3 Installation History
  2.4 Neighbors
  2.5 Satellite Installations

- Chapter 3 -- Military Mission

  3.1 Overview
  3.2 Natural Resources Needed to Support the Military Mission
  3.3 Effects of the Military Mission on Natural Resources
  3.4 Effects of Natural Resources or their Management on the Mission
  3.5 Future Military Mission Impacts on Natural Resources

- Chapter 4 -- Facilities

  4.1 Overview
  4.2 Transportation System
  4.3 Water Supply
  4.4 Projected Changes in Facilities

- Chapter 5 -- Responsible and Interested Parties

  5.1 Installation Organizations
  5.2 Other Defense Organizations
  5.3 Other Federal Agencies
  5.4 State Agencies
  5.5 Universities
  5.6 Contractors
  5.7 Other Interested Parties
  5.8 Signatory Agencies

- Chapter 6 -- Natural Resources and Climate

  6.1 Setting
  6.2 Topography
  6.3 Geology
  6.4 Climate
  6.5 Petroleum and Minerals
  6.6 Soils
  6.7 Water Resources
  6.8 Flora
  6.9 Fauna
  6.10 Threatened and Endangered Species

Table 12.7 (continued):

- Chapter 7 -- Land Use and Management Units

  7.1 Land Uses
  7.2 Management Units

- Chapter 8 -- Natural Resources Management

  8.1 Objectives
  8.2 Forest Management
  8.3 Agricultural/Grazing Outleases
  8.4 Habitat Management
  8.5 Game Harvest Management
  8.6 Rare, Threatened, or Endangered Species Management
  8.7 Furbearer Management
  8.8 Other Nongame Species Management
  8.9 Transplants and Stocks
  8.10 Wetlands Management
  8.11 Water Quality Management
  8.12 Land Rehabilitation and Maintenance
  8.13 Soil Resources Management
  8.14 Cantonment Area Management
  8.15 Pest Management
  8.16 Fire Management
  8.17 Special Interest Area Protection
  8.18 Training Requirements Integration

- Chapter 9 -- Inventorying and Monitoring

  9.1 Objectives
  9.2 General
  9.3 Flora Inventory and Monitoring
  9.4 Fauna Inventory and Monitoring
  9.5 Water Quality Monitoring
  9.6 Soil Resources Inventory and Monitoring
  9.7 Data Storage, Retrieval, and Analysis
  9.8 Five Year Plans

- Chapter 10 -- Research and Special Projects

  10.1 Objectives
  10.2 Research Mechanisms
  10.3 Planned Research/Special Projects

- Chapter 11 -- Enforcement

  11.1 Objectives
  11.2 History and Authority
  11.3 Jurisdiction
  11.4 Enforcement Activities
  11.5 Training

- Chapter 12 -- Environmental Awareness

  12.1 Objectives
  12.2 Military Personnel Awareness
  12.3 Public Awareness

Table 12.7 (continued):

- Chapter 13 -- Outdoor Recreation

  13.1 Objectives
  13.2 Military Mission Considerations
  13.3 Public Access
  13.4 Hunting, Fishing, and Trapping Programs
  13.5 Other Natural Resources Oriented Outdoor Recreation
  13.6 Recreation and Ecosystem Management
  13.7 Safety and Security

- Chapter 14 -- Cultural Resources Protection

  14.1 Objectives
  14.2 Cultural and Historic Resources
  14.3 Natural Resources Management Implications

- Chapter 15 -- National Environmental Policy Act

  15.1 Objectives
  15.2 NEPA Responsibilities and Implementation
  15.3 NEPA and Natural Resources Management

- Chapter 16 -- Biopolitical Issue Resolution

- Chapter 17 -- Implementation

  17.1 Organization, Roles, and Responsibilities
  17.2 Manpower
  17.3 Project/Programs Priorities
  17.4 Implementation Funding Options
  17.5 Command Support

- References

- Persons Contacted

- Appendices (as appropriate)

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(4) Adjustment -- choosing strategies for modifying, avoiding, accepting, or otherwise dealing with the ecological risk profile of proposed actions or likely natural events and their cumulative effects; such choices typically involve comparing risk adjustment benefits and costs of various strategies and policy instruments and making difficult tradeoffs among risks and costs;

(5) Implementation -- interpreting the strategy mix in practical standards, guidelines, and incentive systems; strategies can be implemented through modifications in the proposed actions, mitigations for particular cumulative ecological risks, or planned responses under a planned adaptive monitoring program;

(6) Monitoring -- tracking the effectiveness of the ecological risk adjustment strategies by measuring exposure pathways and risk endpoints with the focus on "signal" events that could trigger adaptive responses; and

(7) Risk communication -- translating the results of one phase to another, between ecosystem managers, scientists, policy makers, and the public; recent approaches emphasize multi-way communication with an emphasis on understanding the mental models and belief systems which people use for ecological risk assessment. Risk communication involving clarity, completeness, accuracy, and compatibility with information processing styles needs to be built into every phase.

SUMMARY

Cumulative effects issues related to biodiversity and ecosystem management have recently come to the forefront in environmental management and project or program decision-making. These issues are broader in space and time than the traditional biological (ecological) issues included in the EIA process focused on the direct and indirect effects of a single project. As such, they are probably more important for inclusion in SEAs than project-level EIAs, although unique requirements should be considered for each proposed project. As experience is gained, improvements can be expected regarding the incorporation of biodiversity and ecosystem management within the EIA process, including attention to mitigation opportunities for undesirable cumulative effects.

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CHAPTER 13

COMPUTER-BASED TECHNOLOGIES FOR INFORMATION PROCUREMENT AND COMMUNICATION

A key challenge in the environmental impact assessment (EIA) process in general, and in cumulative effects assessment (CEA) specifically, is keeping up with the "explosion of available information" in this computer age. For example, computer-based searching of abstracts of published literature related to EIA has been available for over 15 years. A second generation of computer-based technology involving the Internet, e-mail, and the World Wide Web can also be useful in the EIA process and for cumulative effects studies. A third example involves usage of the growing number of CD-ROMs (computer disk-read only memory) and computer software with EIA or CEA related information. This chapter highlights information related to these three examples.

COMPUTER-BASED BIBLIOGRAPHIC SEARCHING AND DATA RETRIEVAL

A useful source of information for the EIA process and cumulative effects considerations is represented by computerized bibliographic retrieval systems. These systems provide a fast, efficient means of conducting literature searches that produce lists of titles and abstracts of published materials relative to specifically identified topics (based on identified key words or descriptor words). There are several commercial companies (one example is Dialog) that provide access to traditional systems such as the National Technical Information Service (NTIS), Air Pollution Technical Information Center (APTIC), Biosis Previews, Water Resources Abstracts, Compendex, Pollution Abstracts, Agricola, Smithsonian Scientific Information Exchange (SSIE), and Enviroline. In searching any of the systems it is necessary to use key words from that data base or the results will not include all available information. Once the topic to be searched is properly defined, it is easy to query that selected data base on the publications currently available in the subject area.

Usage of computerized bibliographic retrieval systems for identifying relevant information is a valuable initial step in the conduction of an environmental impact study incorporating CEA. The general purpose is to provide the study team with a sense of the currently available literature on the technical aspects of the project. Searches can also be useful in identifying potential direct, indirect, and cumulative impacts, technical methodologies for predicting impacts, and potential mitigation measures. Abstracts or citations for identified references can be procured and, through the elimination of nonrelevant items, the total of pertinent references can be reduced to a manageable number for detailed review.

Bibliographic searching can also be useful in identifying key professionals, professional societies, universities, and research institutes related to a specific impact study or cumulative effects concerns. Key professionals can be identified via their authorship of relevant publications. Useful information can often be obtained from professional societies associated with substantive areas such as engineering, geology, planning, biology, and archaeology. Contacts with these professional societies can also facilitate the identification of key

individuals and lead to pertinent reports and other studies. Special interest groups such as bird societies, nature conservation clubs, and commercial development organizations may also provide relevant information for specific studies.

A large number of military facility reports on environmental impact studies and related topics, including cumulative effects, are maintained at the Defense Technical Information Center (DTIC). Computer-searching by keywords can be used to identify topical reports which can be purchased for a reasonable fee. Information on the DTIC can be obtained by contacting the Defense Technical Information Center, 8725 John J. Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6128 USA; telephone: 703-767-9194.

Information for the EIA process and cumulative effects studies can also be procured from local universities and research institutes as well as regional or national research organizations focused on particular issues or substantive areas. Local universities can provide potentially relevant unpublished studies, theses and dissertations, and published reports on research projects. Research institutes can also provide information associated with both unpublished work and published reports. The identification of pertinent universities and research institutes can be obtained via direct authorship of relevant publications, or via specific individual authors affiliated with universities or research institutes.

A large amount of environmental data can be found in computerized information storage and retrieval systems (Canter, 1996). Examples from the United States include air quality data (U.S. Environmental Protection Agency Storage and Retrieval of Aerometric Data System -- SAROAD), meteorological data (U.S. National Oceanic and Atmospheric Administration Climatic Center), water quality data (U.S. Environmental Protection Agency Storage and Retrieval of Water Quality Data System -- STORET), water quality and quantity data (U.S. Geological Survey National Water Data Exchange System -- NAWDEX, and U.S. Geological Survey National Water Data Storage and Retrieval System -- WATSTORE), terrestrial and aquatic biological data (U.S. Forest Service Wildlife and Fish Assessment System -- WAFA), threatened or endangered species (U.S. Fish and Wildlife Service Endangered Species Information System -- ESIS), and socioeconomic data (U.S. Bureau of Census). Numerous additional examples can be identified through the World Wide Web.

Another potentially valuable source of information in many studies is newspaper reports relating to plans, policies, and/or projects. Review of this historical record of newspaper accounts in a potential project area can be a useful source of background information, even if it is not directly used in the environmental impact study. Several newspaper data bases are available for computer searching. Finally, there are a number of specialized computer systems and software which are being developed; examples include those oriented to land usage and geographical areas, and required permits from local, state, and federal agencies. Many pertinent systems and software can be identified via the World Wide Web.

USE OF THE INTERNET

The Internet is a worldwide computer network which is comprised of multiple networks connected by the international phone system (Okotie, 1995). This worldwide system of computer networks had its origin for military purposes in 1969 (Eide, 1998). Currently, the Internet provides the opportunity for communicating on millions of topics by millions of persons. The most widely used part of the Internet for information

gathering and dissemination is the World Wide Web (or simply, the Web). The number of Internet users is expanding at an unbelievable rate. In 1997, it was estimated that users worldwide exceeded 100 million, and by the year 2000, there may be over 400 million users (Anonymous, 1997).

The Internet can be used for sending/receiving electronic mail (e-mail); subscribing to specific interest lists; procuring information on a variety of EIA or CEA-related policy, regulatory, and technical issues; and identifying topical area experts. Job searching can be done on the Internet (Petty, 1997a). In addition, Okotie (1995) suggested that public participation programs related to EIA could be facilitated by the Internet. Summary information on the proposed project could be provided by the proponent, and interested individuals and/or groups could provide feedback. Further, complete EIA documents such as EAs (environmental assessments) and/or EISs (environmental impact statements) could be made available via the Web. Table 13.1 lists several additional specific examples of uses of the Internet in the EIA process.

The most used service on the Internet is electronic mail, referred to as e-mail (Anonymous, 1997; and Eide, 1998). Information dissemination via e-mail attachments thereto is also becoming commonplace. For example, the periodic newsletter (6 to 10 pages in length) of the Association of Environmental Engineering Professors (AEEP) is sent to all members via their e-mail addresses.

Topical discussion groups related to EIA or CEA can also use the Internet. Examples of listserver discussion groups available through the International Association for Impact Assessment (IAIA) include:

(1) **IAIA_SIA** which deals with social impact assessment;

(2) **IAIA_EUROPE** which deals with impact assessment issues in Europe;

(3) **IAIA_URBAN** which deals with urban environmental issues; and

(4) **IAIA_PROFDEV** which is about professional development issues in EIA and also related to IAIA itself.

Basic Reference Materials

Table 13.2 lists seven books and one report related to environmentally focused uses of the Internet or to fundamental information about the Internet. Three books related to Internet usage are available (Schupp, 1995; Briggs-Erickson and Murphy, 1997; and Katz and Thornton, 1997). All three describe the Internet concept and include fundamental information on its usage. The original book by Schupp (1995) is organized into five chapters. The first chapter contains a compilation of over 100 environmentally related on-line discussion groups and information dissemination services. Chapter 1 also includes mailing lists which can be used to rapidly find U.S. Environmental Protection Agency (EPA) news releases, Federal Register documents, and exchange information on regulatory compliance. Environmentally related Usenet news groups (similar in many respects to mailing lists) are discussed in Chapter 2. Chapter 3 describes ten additional sources of environmental information that Internet users can access by e-mail. Chapter 4 deals with electronic journals and newsletters which address a wide range of scientific, technical, and policy issues related to the environment. The final chapter (Chapter 5) documents bulletin board systems (BBSs) that offer users access to an assortment of environmentally related databases, text files, and conferences. Examples of BBSs described in Chapter 5 are

Table 13.1: Examples of Uses of the Internet in the EIA Process

- Use of e-mail to send project description and related environmental information to individuals/agencies/organizations and seek their input in the scoping process.
- Use of e-mail to individuals/agencies/organizations for purposes of announcing scoping-related meetings.
- Facilitation of input from discussion groups (listservers) on topical issues.
- Identification of subject matter experts who could provide special input or review of impact study documents.
- Identification of consulting firms and their capabilities for conducting impact studies in general, or studies on specific types of projects or topical issues.
- Identification of relevant technical reports from various agencies, companies, or organizations related to impact studies for the type of project of interest.
- Identification of relevant existing or proposed laws or regulations related to environmental issues or the type of project of interest.
- Identification of key journal articles related to the impacts of concern or the type of project of interest.
- Identification of case studies on similar types of projects (analogs).
- Downloading of available data (historical and current) for describing the physical/chemical, biological, cultural, and socioeconomic components of the affected environment.
- Downloading of models (or related software) which can be used for predicting the impacts of the type of project of interest.
- Use of e-mail to post public notices about the availability of an environmental assessment (EA) or environmental impact statement (EIS) on the proposed project, plan, program, or policy; use of agency Web site to post similar information.
- Placement of draft EA, EIS, or summaries thereof, on the agency Web site and request comments on the document.
- Identification of EIA training courses.
- Placement of consultant company information, experience, and services on the company Web site; the company may attract EIA business as a result.

Table 13.2: Examples of Internet-related Information

TOPIC	COMMENTS
Environmental Guide to the Internet (Briggs-Erickson and Murphy, 1997)	Third edition of an earlier book by Schupp (1995) focused on environmental, ecological, and conservation Web sites. Includes information on more than 200 e-mail discussion groups, 35 newsgroups, 126 newsletters and electronic journals, and 523 Web sites. Brief information is included on each of these information sources.
Recycling and Waste Management Guide to the Internet (Guttentag, 1997)	Book focused on the management of nonhazardous solid wastes through recycling or other methods such as waste reduction, reuse, energy recovery or land disposal. Includes information on relevant e-mail discussion groups, newsgroups, and a large number of Web sites.
Environmental Management Tools on the Internet (Katz and Thornton, 1997)	Book on the use of the Internet for various environmental management issues. See Table 16.5 for table of contents.
Chemical Guide to the Internet (Lee, 1996)	A specialized book on chemical and chemical engineering information useful in identifying emission concerns and environmental transport and fate issues.
GLEEN: Global Energy and Environment Network Project--Internet Energy and Environment Sampler (RCG/Hagler, Bailly and Co., Inc., 1995)	Report emphasizing electronic sources of information on energy and environment. Web sites and bulletin board systems (BBSs) which are free are identified along with fee-based or restricted information sources. Brief descriptions of Web sites and BBSs are provided.
Safety and Health on the Internet (Stuart, 1996)	Book focused on safety and health issues within industry, including items related to EIA.
Official Internet Dictionary--A Comprehensive Reference for Professionals (Bahorsky, 1998)	Fundamental book on the workings and language of the Internet, including e-mail, electronic mailing lists, and other Internet functions.
Internet and the Law: Legal Fundamentals for the Internet User (Kurz, 1996)	Book focused on basic principles related to laws of copyright, trademark, trade secret, patent, libel/defamation, and licensing. These topics have arisen as the Internet has experienced its phenomenal expansion.

listed in Table 13.3 (after Schupp, 1995). The Briggs-Erickson and Murphy (1997) book represents a third edition of the 1995 book by Schupp. Documentation of relevant BBSs is available. For example, a manual has been prepared on the functions of the air pollution control BBS named RACT/BACT/LAER Clearinghouse (Steigerwald, 1997). The manual describes how to connect, search, view, and retrieve information from this BBS.

The Katz and Thornton (1997) book summarizes regulatory chemical-specific, water, land/soil, air, and hazardous waste information which can be procured from the Internet for free. Information is also included on several data bases which can be queried for a fee.

Specialized Internet books with relevance to the EIA process are also being generated. For example, a chemical guide was published in May, 1996 (Lee, 1996) and a safety and health guide in December, 1996 (Stuart, 1996). The Lee (1996) book is oriented to chemical and chemical engineering information useful in identifying emission concerns and environmental transport and fate issues. Chapter 1 contains descriptions of 512 selected organizations and Chapter 2 addresses 541 World Wide Web resources by subject. Chapter 3 highlights 348 academic institutions. Chapters 4 through 6 focus on 46 Internet discussion lists, 40 news groups, and 43 gopher resources, respectively. The Stuart (1996) book can be useful in addressing human health impacts within the EIA process. In addition to fundamental Internet-related information, the book identifies 129 web and gopher sites, 61 mailing lists, and 13 news and discussion groups.

In addition to more specialized books, there are numerous general books available for "surfing the Net"; such "primer books" can be useful to the beginner in tapping the vast sources of potentially relevant information for the EIA process.

Finally, it is important to remember that the Internet and everything on it is a "work in progress" (Schupp, 1995). Material is added, changed, or even deleted on a daily basis. Frequent topical searching of the Internet can increase the user's confidence and enhance the identification and procurement of relevant information for the EIA process and cumulative effects studies.

Examples of Web Sites

From a communication and technical perspective, Web sites should be visually appealing, have a logical layout, and contain information related to scientific and policies issues on substantive topics (Strock, 1998). This chapter section is primarily focused on examples of Web sites which are either directly or indirectly related to the EIA process, including CEA.

The Council on Environmental Quality (CEQ) in the United States activated a Web site called NEPANet in March, 1995 (http://ceq.eh.doe.gov/nepa/nepanet.htm). NEPANet primarily contains information related to the EIA process in the United States (Council on Environmental Quality, 1997). NEPANet is maintained and updated by the U.S. Department of Energy (Jessee, 1998). Table 13.4 displays the topical contents within NEPANet as of June 10, 1998.

The U.S. Department of Energy activated its NEPA Web site in October, 1993 (http://tis.eh.doe.gov/nepa/). Table 13.5 summarizes the type of information available on the DOE NEPA Web site (Jessee, 1998).

Table 13.3: Examples of Bulletin Board Systems Available Through Internet (after Schupp, 1995)

EPA Office of Air Quality Planning and Standards Technology Transfer Network
Aeromatic Information Retrieval System (AIRS)
Ambient Monitoring Technology Information Center (AMTIC)
BLIS (air pollution control technologies)
Clean Air Act Amendments (CAAA)
Clearinghouse for Inventories and Emission Factors (CHIEF)
COMPLiance Information (COMPLI)
Control Technology Center (CTC)
Emission Measurement Technical Information Center (EMTIC)
NATICH (national air toxics information clearinghouse)
New Source Review (NSR)
Office of Mobile Sources (OMS)
Office of Radiation and Indoor Air (ORIA)
Support Center for Regulatory Air Models (SCRAM)
FedWorld
The Superfund Early Bird Window
U.S. Bureau of Mines Bulletin Board Network (BOM-BBN)
Superfund Data and Information Bulletin Board (CLU-IN)
Pesticide Special Review and Reregistration Information System (PSRRIS)
Wastewater Treatment Information Exchange (WTIE)
Offshore Oil and Gas Data Bulletin Board
Alternative Treatment Technology Information Center Bulletin Board (ATTIC)
Drinking Water Information Processing Support System (DRIPSS)
Pesticide Information Network (PIN)
Nonpoint Source Program (NPS) Bulletin Board
Drinking Water Information Exchange (DWIE)
U.S. Federal Aviation Administration Office of Environment and Energy BBS
RACT/BACT/LAER Clearinghouse
Cleanup Standards Outreach Bulletin Board System (CSOBBS)
Gulf Coast Pollution Information Bulletin Board (GULFLINE)
U.S. Department of Commerce Economic Bulletin Board
Government Printing Office BBS

Table 13.4: Topical Contents of NEPANet as of June 10, 1998

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

- Full Text Statute (NEPA)
- Regulations for Implementing NEPA from CEQ and the Agencies
- Agency NEPA Web Sites
  - EPA's Office of Federal Activities
  - Department of Energy NEPAWeb
  - Department of Defense DENIX
  - Department of the Interior Bureau of Land Management
  - Air Force Center for Environmental Excellence
  - Federal Highway Administration - Region 3
  - General Services Administration
  - U.S. Geological Service Environmental Affairs Program
  - Department of Agriculture
    - USDA Natural Resources Conservation Service
    - US Forest Service

- Guidance from CEQ
  - Scoping
  - 40 Most Frequently Asked Questions
  - Guidance Regarding the NEPA Regulations
  - Pollution Prevention

CONSIDERING CUMULATIVE EFFECTS UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT (a report)

NEPA--A STUDY OF ITS EFFECTIVENESS AFTER 25 YEARS (a report)

CEQ ANNUAL REPORTS

- 1996 Annual Report of the CEQ (coming soon)
- 25 Anniversary Report of the CEQ (1994-95)
- 1993 Annual Report of the CEQ

ENVIRONMENTAL IMPACT ANALYSIS

- Where and How to File an EIS
- EISs Available for Review
- EIS Activity--Statistics
- Digital NEPA Document--Department of Energy
- Environmental Impact Analysis Data Links
- Agency NEPA Points of Contact

ENVIROTEXT RETRIEVAL SYSTEM

- EnviroText is an on-line searchable library that provides easy access to environment, safety, and health federal and state statutes and regulations, as well as Indian Tribal Codes and Treaties, and international agreements.

ENVIRONMENTAL ORGANIZATIONS

- National Association of Environmental Professionals (NAEP)
- International Association for Impact Assessment (IAIA)

Table 13.4: (continued)

INTERNATIONAL ENVIRONMENTAL IMPACT ASSESSMENTS (EIA)

- Antarctica
- Australia
- Canadian Environmental Assessment Agency
- Georeferenced Population Data Sets of Mexico
- International Association for Impact Assessment (IAIA)
- Japan's National Institute for Environmental Studies
- Land Information New Zealand (LINZ)

NEPA BIBLIOGRAPHIC INFORMATION

- NEPA Case Law Review
- NEPA Bibliography

NEPA TRAINING INFORMATION

- CEQ Compendium of NEPA Training
- Duke University NEPA Courses
- USDA Graduate School (available soon)

Table 13.5: Information Available on DOE NEPA Web Site (Jessee, 1998)

The DOE NEPA Web site is organized into five functional modules that enable users to easily navigate their own path to NEPA information.

(1) DOE NEPA Announcements: Quick-reference announcements of DOE NEPA events, including public involvement opportunities and links to Federal Register notices.

(2) DOE NEPA Analyses: Full-text and retrieval of EISs, environmental assessments (EAs), notices of intent, records of decision, and mitigation action plans, links to other agency NEPA documents; a master list of all DOE EISs.

(3) NEPA Links: Quick access to Web sites of CEQ's NEPAnet, EPA's Office of Federal Activities, and other agency and international NEPA-related Web sites. A link to EnviroText provides full texts of federal environmental laws and regulations, Executive Orders, and Native American Tribal codes.

(4) DOE NEPA Tools: DOE NEPA Order and Regulations, DOE NEPA guidance, including compliance and contracting reform guidance, document preparation, and Web publishing standards; the DOE NEPA stakeholder directory; and links to law references and the U.S. Library of Congress.

(5) DOE NEPA Process Information: NEPA implementation reports and milestone data-webs: a listing of EAs and EISs in preparation, fact sheets on DOE weapons complex NEPA reviews, DOE Annual Planning Summaries, and Lessons Learned Quarterly Reports.

"Hotlinks" are being increasingly used to establish linkages between Web sites. A hotlink refers to where the user "clicks" on the highlighted text and is taken from the Web site of origin to another Web site. To illustrate, the U.S. Environmental Protection Agency (EPA) has almost 5000 web pages with links to U.S. Geological Survey (USGS) sites, and USGS has almost 3000 links to EPA (Lanfear and Klima, 1998). Extensive linkages exist between EPA's "Surf Your Watershed" site (http://www.epa.gov/surf/) and the USGS's "Water Resources of the United States" site (http://water.usgs.gov/). The USGS site includes historical streamflow data, real-time water quantity and quality data, water-use data, pertinent reports, and software for hydrologic analysis and modeling. These watershed and water-related sites can be useful in addressing cumulative effects on water resources.

Table 13.6 identifies several examples of Web sites related to the EIA process, with still additional Web site addresses for agencies and organizations contained in Table 13.7 (Davis, 1998).

Miscellaneous examples of Web sites which can be useful in the EIA process and for CEA include:

(1) air dispersion modeling software (www.beeline-software.com)

(2) decision process guidebook of the U.S. Bureau of Reclamation (www.usbr.gov/Decision-Process/execsum.htm)

(3) information on the USGS's Instream Flow Incremental Methodology (IFIM) for aquatic impact assessment, as well as related training courses, IFIM software, and decision support systems (http://www.mesc.nbs.gov/rsm)

(4) National Marine Fisheries Service (http://kingfish.ssp.nmfs.gov/)

(5) Canadian Department of Fisheries and Oceans (http://www.ncr.dfo.ca/)

(6) water resources software from the U.S. Geological Survey (http://water.usgs.gov/software/)

(7) new publications of the U.S. Geological Survey (http://pubs.usgs.gov/publications/)

(8) water resources reports from the U.S. Geological Survey (http://water.usgs.gov/public/wrd012.html)

(9) digital data sets of aquifer characteristics from the U.S. Geological Survey; for example, for Oklahoma data (http://www.ok.cr.usgs.gov/gis/aquifers/index.html) (Note: these data sets are also available on diskette.)

(10) in February, 1998, the U.S. Environmental Protection Agency established the National Environmental Publication Information (NEPI) site which contains over 6,000 EPA publications; these publications can be searched and viewed (http://www.epa.gov/cincl/)

(11) jobs page of the National Ground Water Association (www.ngwa.org)

(12) Water Science and Technology Board of the National Academy of Science/National Research Council (http://www_2.nas.edu/wstb)

Table 13.6: Examples of Web Sites (agencies, data bases, and organizations) Related Directly or Indirectly to EIA and/or CEA (compiled from International Association for Impact Assessment, 1997; Lohani, et al., 1997; National Association of Environmental Professionals, 1996 and 1998; and individual contacts)

ACCESS EPA: An Environmental Directory (http://earth1.epa.gov/Access/) This is a directory of the U.S. Environmental Protection Agency (EPA) and other public sector environmental information resources. Its many resources include information centers, publications, library resources, data systems, models, bulletin board systems, clearinghouses, CD-ROMs, and software applications. The user can browse through an extensive list of environmental topics. (A hard copy of the directory is available--see reference to U.S. Environmental Protection Agency, 1996.)
Albert's Virtual Homepage (http://www.helsinki.fi/~sigurdss) This homepage contains many links to EIA, environmental issues, and environmental auditing and management sites.
Australian EIA Network (http://www.erin.gov.au/net/eianet.html) The Australian EIA Network contains many resources. There is information regarding legislation and agreements, case studies, contacts for practitioners in the commonwealth and state/territory governments, information about EIA in Australia, EIA training resources, and links to other environmental servers.
Bibliography of Biodiversity Assessment Methodologies (http://www.erin.gov.au/life/general_info/biodiv_assess_intro.html) Updated monthly, this Web site provides a large bibliography of assessment methodologies. A search for "impact assessment" provides many helpful resources.
Canadian Environmental Assessment Agency (CEAA) (http://www.ceaa.gc.ca/) Information on the CEAA is provided on the homepage. There is a public registry of information, links to other environmental assessment sites, and study reports of environmental assessment effectiveness.
Directory of Environmental Resources on the Internet (http://www.envirosw.com/) This site contains an extensive number of listings and links to various environmental resources on the Internet such as seminars, courses, education resources such as libraries and reports, consultants and services, links to a handful of environmental sites, and links to legislative information.
Earthvision (http://www.earthvision.net) Earth Vision is an information network that allows environmental stakeholders at all levels to exchange timely information affecting the global community in the areas of sustainable development, policy and advocacy, education, business and technology, and recreation.

Table 13.6: (continued)

3E (Earth's Environmental Experts) Database of Environmental Experts (http://www.nhbs.co.uk/3e/index.html) This database consists of individual experts and specialists in a wide range of professions such as acoustics, biology, chemistry, climate, conservation, ecology, engineering, environment, hazard and risk, restoration, toxicology, water, wildlife, etc. The database may be searched free of charge.
Ecological Risk Analysis: Tools and Applications (http://www.hsrd.ornl.gov/ecorisk/ecorisk.html) Information, provided by Oak Ridge National Laboratory, is included which can be used to conduct ecological screening and baseline risk assessments. The site includes a database of benchmarks for aquatic organisms, wildlife, and sediments; guidance documents for performing environmental assessments; and links to other assessment sites.
Envirolink (http://envirolink.org/) This site provides a compilation of comprehensive, up-to-date environmental resources available through the Web. It has links to sites covering just about any topic related to the environmental field, including risk assessment.
Environmental Data Interactive Exchange (http://www.edie.net) This Web site includes a global marketplace section, a searchable reference library, weekly news summaries, networking opportunities, and a technology database that enables users to compare the latest equipment and services available in the environment and water sectors.
Environmental Route Net (http://www.csa.com/routenet) Environmental Route Net provides access to hundreds of specialized Internet sites by providing users with a few menu-driven instructions. The site contains links to the latest environmental news, environmental regulations and legislation, USA and international environmental patents and other reference information.
Environmental Treaties and Resource Indicators (http://sedac.ciesin.org/entri/) This service is an on-line tool that integrates data about the content and status of international environmental treaties with data about national resource indicators, i.e., national-scale socioeconomic, environmental, and earth science variables (including data derived from remote sensing). The environmental treaties and national resource indicators included cover nine global environmental issues: climate change, ozone depletion, air pollution, desertification and drought, conservation of biological diversity, deforestation, oceans and their living resources, trade and the environment, and population.
Environmental World Wide Web Servers (http://iridium.nttc.edu/env/env_links.html) This is an alphabetical listing of sites to connect to various environmental information sources. It is divided by government, corporate, military, universities, and others.

Table 13.6: (continued)

Envirosense (http://es.inel.gov/) This Web site is the EPA's pollution prevention forum for all levels of government, researchers, industry, and public interest groups. Its goal is to become a single repository for pollution prevention and the related issues of compliance assurance, enforcement information, technological information, databases, etc.
Environmental Software Services (ESS) GmbH, Austria (http://www.ess.co.at/) This small Austrian research company Web site contains information on the customized environmental information and decision-support systems that it designs, develops, and deploys. The list of environmental sites and gophers provided are quite comprehensive, and there is information about the projects and research done for the proposals.
EPA's Air Pollution Database -- AIRS (http://www.epa.gov/disc/airs/airs.html) This is a repository of resources relevant to airborne pollution in various countries. Among the extensive list of resources is data from monitoring systems, a list of air pollution point sources, reference data, illustrative maps and charts, and a technology transfer network.
ESSA Software, Ltd. (http://www.essa.com) This site contains information regarding ESSA's EIA-support software applications. They have developed the world's first environmental assessment screening expert system called calyx. Their PC-based programs allow users to preview potential environmental impacts before they happen.
GEMI (http://www.gemi.org) The Global Environmental Management Initiative's homepage provides a new tool for businesses seeking to achieve environmental health and safety excellence. The GEMI homepage is organized into five main areas; information about GEMI, members, publications, what's new, and the 1996 conference.
Institute for Environmental Assessment (IEA) (http://www.green channel.com/iea) IEA is a professional organization in the United Kingdom established to promote best practice standards in environmental assessment and auditing. Its independence is maintained by a growing membership drawn from environmental consultancies, industry, local authorities, and educational establishments.
Intercept, Ltd. (http://www.intercept.co.uk) This Web site contains information on over 500,000 books and reports organized by author and subject, with many subjects related to the EIA process. To serve as an illustration, many reports from the United Nations Environment Program can be found at this site.
International Association for Impact Assessment (IAIA) (http://IAIA.ext.NoDak.edu/IAIA/) This site contains information regarding IAIA, as well as direct links to professional Internet sites (such as the Australian EIA Network, International Rivers Network, Econet, etc.), the Impact Assessment Journal, and the IAIA Newsletter. Its resources section covers ten areas in impact assessment, including risk assessment, social impact assessment, policy assessment, and training.

Scotland 99. Summer available on CD-ROM

Table 13.6: (continued)

International Institute for Environment and Development (http://www.oneworld.org/iied/resource/) The Directory of Impact Assessment Guidelines contains bibliographies and summaries of many different resources and provides information as to how to obtain the resources. There is also an International Environmental and Natural Resource Assessment Information Service (Interaise) which contains national conservation strategies and sustainable development strategies.
International Institute for Sustainable Development (IISD) (http://iisd1.iisd.ca/) The IISD homepage contains many documents regarding sustainable development, including ISO14000 information. There is a search function with the ability to choose a specific country and an EIA database.
ISO 14000 (http://www.gasweb.org/gasweb/ias/iso14000.htm) International Approval Services has established a Web site that contains detailed information about the environmental management system (EMS) standard and how an organization can register its EMS to the standard. The site also contains links to popular environmental organizations and resources located throughout the Web.
MSDS On Line (gopher://gopher.chem.utah.edu/11/MSDS) An alphabetical index and listing of pertinent chemical and safety information arranged in an easy to view format can be found at this site.
NAEP (http://www.naep.org) The National Association of Environmental Professionals' homepage features information on issues affecting environmental professionals, a reading room for the latest information and technology, as well as areas where you can "NET-work" with other environmental professionals and join-in on discussion groups.
National Technical Information Service (http://www.ntis.gov) This Web site is a useful research tool to determine pricing and the availability of government manuals, handbooks, computer products, and audiovisuals related to numerous environmental topics, including environmental impact statements and environmental assessments.
Natural Environment Research Council (NERC) (http://www.nerc.ac.uk/) The United Kingdom's environmental monitoring network collects, stores, analyses, and interprets long-term data based on physical, chemical, and biological variables which respond to environmental change. The databases contain a wealth of information and links. The link to environmental servers which can be found under "information sources outside NERC" is excellent.
Oak Ridge National Laboratory Energy Efficiency and Renewable Energy Program (http://www.ornl.gov/ORNL/Energy_Eff/Energy_Eff.html) This Web site describes research and development in the field of sustainable energy technology. It features descriptions and news about ORNL programs as well as search engines and databases. Information is provided about sustainable technologies that are in the process of development.

Table 13.6: (continued)

Renew America (http://solstice.crest.org/renew_america) Renew America's *Environmental Success Index* features a compilation of 1,600 of the most successful environmental programs that can be used as models for other communities in a national effort to protect, restore, and enhance the environment.
Sierra Club (http://www.sierraclub.org:80/) Sierra Club's homepage contains links to numerous magazines, newsletters, and articles and addresses topics such as global warming, environmental education, and various policies. It contains many links to other Internet resources.
UNEP - Industry and Environment (http://www.unepie.org) Located in Paris, France, this center's mission is to promote cleaner and safer industrial production and consumption. This site provides information about the following program areas (as well as others): prevention of industrial accidents and minimization of impacts (APELL), environmental management and pollution control of selected high-risk sectors, preventative strategies for cleaner and more efficient production, environmental technology assessment, and outreach to industry to stimulate dialogue and initiatives on sustainable development. There are two databases available, one of which is called the *International Cleaner Production Information Clearinghouse*, which provides information about clean technologies.
University of Manchester, EIA Centre (http://www.art.man.ac.uk/eia/EIAc.html) The EIA Centre's homepage contains EIA newsletters, an EIA leaflet series, various papers, EIA Centre publications, a list of Centre training activities, and documents regarding developing country initiatives in EIA.
U.S. Department of Energy (DOE) Office of Environmental Management (http://www.em.doe.gov/index.html) This site contains information on topics related to environmental management, including waste management, environmental restoration, pollution prevention, and science and technology.
U.S. Department of Energy (DOE) Technical Information Services (TIS) (http://tis.eh.doe.gov/) This site is a collection of information sources related to safety and health. It includes an information center, documents, publications, regulatory information and guidelines, and offers access to several databases. The databases include *Populations at Risk to Environmental Pollution*, *Risk Information Management System*, and many others.
U.S. Environmental Protection Agency (http://earth1.epa.gov) The U.S. Environmental Protection Agency has a homepage that gives access to information about EPA offices and regions, calendars and announcements, regulations, EPA standards, science and research, newsletters and journals, and database resources.
U.S. Environmental Protection Agency (EPA): Federal Register (http://www.epa.gov/Rules.html) This site contains the full text of selected Federal Register documents that deal with the environment or environment-related issues. It also contains a daily table of contents of the Federal Register.

Table 13.6: (continued)

U.S. Environmental Protection Agency and Purdue University Software for Environmental Awareness (http://www.epa.gov/glnpo/seahome/) This address contains more than 40 environmental software programs from USEPA. It offers free interactive software, including risk assessment and environmental assessment. *Environmental Assessment Resource Guide* (EARG) is a generic source of information to facilitate the conduction of EAs for many types of projects. "Scoping," generation of alternatives, impact identification and analysis, mitigation and decision making are among the topics covered. *Comparative Risk Assessment* outlines the history and methodology of comparative risk assessment. Case studies and information sources are provided. It provides a framework for prioritizing environmental problems and is suited for a wide range of users.
World Bank Homepage (http://www.worldbank.org) In its "Topics in Development" section, the World Bank's *Global Environment Facility* contains environmental information, documentation, and publications. It also describes environmental programs and includes many relevant links.
WWW Virtual Library - Sustainable Development (http://www.ulb.ac.be/ceese/sustvl.html) Maintained by the Université Libre de Bruxelles, this site contains a list of links to organizations, projects/activities, up-coming events, libraries, documents/references, electronic journals, databases, and other relvant sites.

"Enviroleg"

www.enviro.law

Table 13.7: Additional Potentially Useful Web Site Addresses (Davis, 1998)

Government Agencies/Programs
U.S. Department of the Interior (www.doi.gov/)
National Wetlands Inventory (www.nwi.fws.gov/)
U.S. Bureau of Reclamation (www.usbr.gov/)
U.S. Environmental Protection Agency--solid wastes (www.epa.gov/epaoswer/)
U.S. Environmental Protection Agency--pesticides and toxic substances (www.epa.gov/internet/oppts/)
U.S. Environmental Protection Agency--Superfund (www.epa.gov/superfund/)
U.S. Nuclear Regulatory Commission (www.nrc.gov/)
U.S. Fish and Wildlife Service (www.fws.gov/)
U.S. National Park Service (www.nps.gov/)
U.S. Bureau of Land Management (www.blm.gov/)
U.S. Forest Service (www.fs.fed.us/)
Nongovernmental Organizations
Friends of the Earth (www.foe.org/)
Natural Resources Defense Council (www.nrdc.org/)
American Petroleum Institute (www.api.org/)
Edison Electric Institute (www.eei.org/)
Chemical Manufacturers Association (www.cmahq.com/)
Izaak Walton League (www.iwla.org/)
Trout Unlimited (xenon.prozima.com:880/)
American Water Works Association (www.awwa.org/)
Greenpeace (www.greenpeace.org/cnuk.html)
Audubon Society (www.audubon.org/)

(13) National Aerial Photography Program Online Database of the U.S. Geological Survey (http://edcwww.cr.usgs.gov/webglis/glisbin/search.pl?)

(14) remediation Web site of the U.S. Army Environmental Center (http://aec-www.apgea.army.mil:8080)

(15) on-line resources related to ground water (www.groundwater .com)

(16) United Nations Environment Program (http://www.unep.org)

Five Web sites related to soil and ground water remediation include (Strock, 1998):

(1) TechKnow (www.gnet.org)

(2) Clu-In, Hazardous Waste Clean-up Information (http://clu-in.com)

(3) Research Center for Groundwater Remediation Design (RCGRD) (www.rcgrd.edu)

(4) Ground Water Remediation Technologies Analysis Center (www.gwrtac.org)

(5) Remediation Information Management System (RIMS) (www.remedial.com)

Pollution prevention information which could be used in EIA can also be found on the Web. Three examples of Web site addresses include (Petty, 1997b):

(1) solvent alternatives guide (SAGE) (http://clean.rti.org)

(2) coating alternatives guide (CAGE) (http://clean.rti.org/cage)

(3) pollution prevention environmental design guide (P2EDGE) (http://p2.pnl.gov:2080/DFE/p2edge.html)

The Agency for Toxic Substances and Disease Registry (ATSDR) has developed a comprehensive database called HazDat. HazDat contains information about the release of hundreds of hazardous substances into the environment and the effects of those substances on human health (Perry, et al., 1997). HazDat, which was placed on the Web in 1994, has the following address (atsdr1.atsdr.cdc.gov:8080/hazdat.html.).

The Internet is beginning to be used in training courses. For example, Web site searching for information, including the use of searchable software, has been utilized in job-related training associated with the 1995 Canadian Environmental Assessment Act (Croal, 1997).

A Web-interface database has been developed by Environment Canada for use in the fulfillment of requirements of the Canadian Environment Assessment Act. The database, called the National Environmental Assessment Screening System, or NEAS, can be used in a "Screening mode" to facilitate the preparation of assessments by providing multiple scroll-down and pop-up menus of text (McLean and Michaud, 1998). The data

entered in NEAS can then be used to develop statistics and reports related to the EIA process.

The Institute for Water Resources of the U.S. Army Corps of Engineers is developing a guide for identifying and describing information on natural resources in the United States that is available on the Web (Doll, et al., 1998). Examples of Web sites to be included in the guide include:

(1) Federal sites
- Biosphere Reserves
- Chesapeake Bay Program
- Endangered Species Act of 1973, as amended--Endangered Species Program
- Migratory Nongame Birds of Management Concern in the United States
- National Marine Sanctuary Program
- National Wildlife Refuge System
- North American Waterflow Management Plan
- Wetlands of International Importance, and
- Wild and Scenic Rivers Act of 1968--National Wild and Scenic Rivers System

(2) Nonprofit sites
- National Audubon Society--WatchList of Species
- The Nature Conservancy, and
- Western Hemisphere Shorebird Reserve Network

(3) State sites
- State Natural Heritage Programs (Montana and Arkansas, as examples)
- State departments of natural resources (Colorado, as an example)
- State departments of fish and wildlife resources (Kentucky, as an example), and
- California Environmental Resources Evaluation System

(3) Local sites
- Everglades Information Network and
- San Francisco Estuary Institute

Online publication of journals is being adopted by some professional organizations. For example, the Air and Waste Management Association is now publishing the Journal of the Air and Waste Management Association in this manner. The Journal can be accessed through the "A&WMA Online Publications" link which is found on the Association's Web site (http://www.awma.org). The user must be an AWMA member with a unique password. In a variation of this practice, the prepublication contents of the journal Environmental Impact Assessment Review can be procured via an e-mail contact (CONTENTSDIRECT@elsevier.uk).

Benefits and Concerns Related to Web Usage

Examples of potential benefits of developing and using Web-related information in the EIA process are listed in Table 13.8 (Jessee, 1998). Further, examples of concerns are highlighted in Table 13.9.

Table 13.8: Examples of Potential Benefits of Using Web-based Information in the EIA Process (Jessee, 1998)

- Allows agencies to share corporate resources, minimizing duplication of effort and the potential for work at cross-purposes;
- Creates a means for sharing baseline environmental data;
- Enables proactive, predictive EIA necessary to anticipate issues before proposals are made and before alternatives are precluded;
- Establishes coordinated monitoring approaches to evaluate the effectiveness of the NEPA/EIA process in agency planning and decision making;
- Enables governments to sustain the commitment to improve and coordinate plans, functions, programs, and resources to fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
- Provides a means for determining the long-run impacts or outcomes of a program or policy;
- Ensures consideration of cumulative effects in strategic environmental assessments (SEAs) that are sometimes overlooked in site-specific analyses;
- Preserves important historic, cultural, and national aspects of societal heritage and maintains an environment that supports diversity and variety of individual choice;
- Enables attainment of the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;
- Achieves a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities;
- Enhances the quality of renewable resources and approaches the maximum attainable recycling of depleted resources.

Table 13.9: Examples of Problems/Issues Which May Arise When the Internet Is Used in the EIA Process

- Problems associated with computer viruses and resultant "damage" to user computer systems.
- Presumption of completeness of information procured from the Internet; however, the information will most likely be incomplete or unavailable from Web sites.
- The "overwhelming" quantity of information which can be found with this situation representing "information overload" regarding users.
- Incompatibilities between computer software, Web servers, computer languages, and older vs. newer software.
- Need for a standardized format for citing reference material and information procured from the World Wide Web.
- Lack of quality control on data and information placed on Web sites. In fact, there is no governing body (or control group) for information placed on the Internet.
- Biased information rather than balanced information related to many impact issues which may be of concern in the EIA process.
- Less-than-uniform access to e-mail and the World Wide Web on the part of many stakeholders and individuals.
- The time requirements associated with more and more searching for less important topics related to the EIA process.
- Web sites which are not regularly updated.

USE OF CD-ROMs AND COMPUTER SOFTWARE

The final example of the information-availability explosion is the growing number of CD-ROMs with EIA and/or CEA-related information. To illustrate, a large number of CD-ROMs related to different aspects of the EIA process are now available. The included information ranges from books and reports to environmental data to models for impact prediction calculations. Following are some examples of potentially useful CD-ROMs:

(1) Cooper's Toxic Exposures Desk Reference with CD-ROM is a handbook and accompanying CD-ROM containing summaries of information on 200 of the most hazardous chemicals used in industry and found in the workplace (Cooper, 1997). For each of the chemicals information is included on physical properties, warning properties and permissible exposure levels, health hazard concerns, exposure routes and effects, and emergency response procedures, among others (http://www.crcpress.com).

(2) RCRA Hazardous Waste Source Disk CD-ROM includes full text, tables, and graphics for the Resource Conservation and Recovery Act, Hazardous and Solid Waste Act Amendments, the Federal Facilities Compliance Act, and parts of Titles 40 and 49 of the Code of Federal Regulation (CFR) covering hazardous waste and hazardous materials transportation. Also included are listings of more than 800 contact names within federal and state agencies, private industry, research institutions, and national databases. This CD-ROM is available from Government Institutes, Rockville, Maryland (e-mail: giinfo@aol.com).

(3) CFR Chemical Lists on CD ROM includes 110 chemical lists from the Code of Federal Regulations (Government Institutes, 1997). The lists encompass those chemicals regulated under various laws by the U.S. Environmental Protection Agency, Occupational Safety and Health Administration, and the U.S. Department of Transportation. Chemicals can be searched across multiple lists. (Note: other commercial companies may offer similar CD-ROMs.)

(4) ATSDR's Toxicological Profiles on CD-ROM consists of profiles of the toxicological effects of numerous hazardous substances, chemicals, and compounds (Agency for Toxic Substances and Disease Registry, 1996). Also included is information on mitigation of health effects. The CD-ROM is indexed and user friendly; further, it can be searched across profiles.

(5) Properties of Organic Compounds on CD-ROM, Personal Edition includes chemical and physical property data and related information on 27,500 of the most commonly used organic compounds (Lide and Milne, 1996). Information can be easily displayed and downloaded to printers and Windows-compatible word processors.

(6) Air CHIEF Version 4.0 is available on CD-ROM and features search and retrieval software (U.S. Environmental Protection Agency, 1995). The entire text of AP-42 (Compilation of Air Pollutant Emission Factors), along with several related data bases, is included. This CD-ROM can be used in developing air pollutant emission inventories.

(7) Environmental Statutes Review Course is a CD-ROM containing a computer-based training course that uses narration and

graphics focused on seven key federal laws--the Resource Conservation and Recovery Act; Emergency Planning and Community Right-to-Know Act; Clean Air Act; Clean Water Act; Comprehensive Environmental Response, Compensation, and Liability Act; Toxic Substances and Control Act; and Federal Insecticide, Fungicide, and Rodenticide Act (U.S. Environmental Protect Act, 1997). Modules on each law also contain interactive exercises and examinations.

(8) Integrated Risk Information System (IRIS) is an extensive database focused on how chemicals affect human health (U.S. Environmental Protection Agency, 1998). IRIS can be used as a key source of information for risk assessments of chemicals of environmental concern. Approximately 500 chemicals are addressed in 15-20 pages each. This extensive database is available on CD-ROM (Government Institutes, 1998).

(9) Risk Management for Hazardous Chemicals (Two Volume Set plus CD-ROM) is an extensive document focused on methods and procedures for managing the risks associated with using hazardous chemicals (Vincoli, 1996).

(10) The Code of Federal Regulations on CD-ROM is offered by governmental agencies through the National Technical Information Service and several commercial companies (examples include Government Institutes, Solutions Software Corporation, and Business and Legal Reports, Inc.). Prices differ with the offeror. Typically, all 50 titles of the CFR are included, with quarterly updates available. The CD-ROM is user friendly and easily searchable. In some cases, only Titles 29 (OSHA), 40 (EPA), and 49 (DOT) are included. State environmental regulations are also available on CD-ROM for about 25 states through Business and Legal Reports, Inc., Madison, Connecticut; phone: 800-7-ASK-BLR (800-727-5257).

(11) EPA Training Library on CD-ROM is focused on specific EPA and OSHA hazardous waste training requirements. This CD-ROM is available from Business and Legal Reports, Inc., Madison, Connecticut; phone: 800-7-ASK-BLR (800-727-5257).

(12) A wastewater treatment course called Operations Training is available on two CD-ROMs from the Water Environment Federation in Alexandria, Virginia (phone: 800-666-0206). The course is user friendly and includes photographs, diagrams, audio-enhanced animations, and videos from actual treatment plants.

(13) Watershed Management is a graduate course delivered via CD-ROM, an Internet bulletin board, and e-mail. The course provides a current overview of integrated watershed management. Information about course contents and requirements is available from:

UBC Continuing Studies
University of British Columbia
Vancouver, British Columbia
(phone: 604-822-1450)
(Web site: http://www.ire.ubc.ca)

(14) Integrated Watershed Management: A Hyper-Media CD-ROM is available from the Institute for Resources and Environment (IRE), University of British Columbia, Vancouver, British Columbia (Web site: http//www.ire.ubc.ca). This CD-ROM is

like an electronic textbook which includes topics on hydrology, water quality, aquatic biota, land use issues, case studies, and several others. Also available from IRE is Urban Watershed Assessment on CD-ROM; this reference focuses on the impacts of urbanization on the health of watersheds.

(15) Ground Water Modeling CD-ROM includes more than 125 software packages related to modeling and geochemistry, including models addressing solute transport and fate. This CD-ROM is available from the National Ground Water Association (Web site: http://www.ngwa.org).

(16) Methods and Guidance for the Analysis of Water (on CD-ROM) is available from the National Technical Information Service (NTIS) of the U.S. Department of Commerce (Web site: http://www.ntis.gov/ordernow/). This CD-ROM includes information on more than 350 drinking water and wastewater methods to test for 776 analytes. It contains the full text of all wastewater methods listed in 40 CFR 136 and all drinking water methods approved at 40 CFR 141, including the 500, 600, and 1600 series methods. Also, available from NTIS is Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846 on CD-ROM). This CD-ROM focuses on testing methods for the various characteristics of solid wastes.

(17) Environment Abstracts on CD-ROM is available from Congressional Information Service, Inc., Bethesda, Maryland. Monthly updates include abstracts selected from 800 English-language scientific journals published in the United States and abroad--including all major environment-related science journals. Environment Abstracts are also available in paper copy. Information can be obtained by the use of e-mail: support@cispubs.com.

Several commercial companies are also producing CD-ROMs which include environmental data bases; one example is:

Earth Info, Inc.
5541 Central Avenue
Boulder, Colorado 80301 USA
Phone: 303-938-1788
Fax: 303-938-8183

The environmental data bases available on CD-ROM from Earth Info, Inc., encompass water quality and hydrology, and climate and atmospheric information.

Numerous "software companies" as well as consulting firms are advertising regarding the availability of modeling software or other management information system (MIS) software which could be used in the EIA process, including cumulative effects predictions. In many cases, the software, with supporting documentation, can be purchased. Four examples will be noted:

(1) MIS software, federal regulations, chemical databases, health and safety training modules, permit recordkeeping systems, and selected environmental modeling software are available from envirowin Software, Inc. Two examples of modeling software are Risk Assistant for Windows VI.1 (for use in rapidly estimating exposures and human health risks from chemicals in the environment) and BREEZE-HAZ Air Force Toxic Dispersion

Model (AFTOX) for Windows (for use in meeting risk management and hazard assessment requirements for facilities storing or handling regulated toxic and flammable substances; these requirements are in Sec. 112 of the 1990 Clean Air Act Amendments; AFTOX is a puff/plume dispersion model for continuous and instantaneous, liquid and gas, surface and elevated releases). Contact

envirowin Sofware, Inc.
P.O. Box 18110
Chicago, IL 66618-0110
Telephone: 800-454-0404
Web site: http://www.envirowin.com

(2) Ground water and surface water related modeling software is available from Scientific Software Group. Examples of software include Processing Modflow for Windows, Visual Modflow, MT3D96 (modular 3-D solute transport model), BioSVE (vacuum enhanced recovery with bioventing), SMS (surface water modeling system for Windows), and WMS (watershed modeling system with HEC-1). Contact

Scientific Software Group
P.O. Box 23041
Washington, D.C. 20026-3041
Telephone: 703-620-9214
Web site: http://www.scisoftware.com

(3) A decision support system for watershed management (named the Watershed Analysis Risk Management Framework or WARMF Version 3.0) is available from Systech Engineering, Inc. WARMF Version 3.0 includes nonpoint source models, pollution loading calculations, water quality modeling for several constituents, and spatial distribution presentations using GIS formats. Contact

Systech Engineering, Inc.
3180 Crow Canyon Place
Suite 260
San Ramon, CA 94583
Telephone: 925-355-1780
Web site: http://members.aol.com/STENGl/)

(4) A multipurpose environmental analysis system, called BASINS, is available from TetraTech, Inc. BASINS includes national databases on streamflow and water quality, specific tools for mining such data, and watershed and water quality models (including NPSM--nonpoint source model, and QUAL 2E--version 3.2). Database and model outputs are integrated within a GIS system for purposes of visual display. Contact

TetraTech, Inc.
10306 Eaton Place, Suite 340
Fairfax, Virginia 22030
Telephone: 703-385-6000
Fax: 703-385-6007

SUMMARY

Opportunities for using computer-based technologies for information procurement and communication within the EIA process are expanding and

changing rapidly. The challenge for EIA practitioners is to keep abreast of such changes and opportunities. Three examples of computer-based technologies addressed herein include bibliographic searching and data retrieval, the Internet, and a variety of CD-ROMs and computer software. Further, it should be noted that information procurement and communication via the Internet provides unique possibilities for making the EIA process more efficient and effective.

Perhaps the most important advantage of Internet usage in the EIA process is related to the cumulative knowledge developed by the user over time. Key Web sites can be identified and used routinely. Useful points of contact for information and data can be developed as a function of project type and location. Further, useful models available on CD-ROMs or in computer software can be aggregated and used on an as-needed basis.

With the above-described examples of the information explosion, it is tempting to think that the EIA process, including CEA, can be fully supported via computer software focused on impact identification, modeling, and interpretation information. However, some cautions in this regard were developed at a workshop in 1996 (Warner, et al., 1997a and 1997b). Specifically, cautions were advanced on three issues: (1) complete dependence on computer-based scoping checklists as a substitution for creative thinking; (2) overreliance on GIS systems when the quality of input data is questionable; and (3) use of EIA software for training in lieu of "hands-on" experience using actual case studies. To partially overcome some of these concerns, it was recommended that "prompts" be incorporated within software and user manuals. These prompts could be used to impress on the user that (Warner, et al., 1997a and 1997b):

(1) a systematic program of stakeholder consultation is integral to identifying impacts and proposing mitigation;

(2) verification of impact inventories should be made through site visits;

(3) there are limitations of checklists and dangers associated with scoring impacts;

(4) impact importance and consequential mitigation should be identified on the basis of a combination of reasoning, values, policies and experience, and not personal judgment alone; and

(5) technical and institutional feasibility studies will probably be needed for all major mitigation proposed.

Finally, an "EIA Workbench" is being developed as a joint effort between several EIA practitioners. The workbench, which will be available on the Web, will contain text material, data, models, environmental standards, and laws and regulations useful within the EIA process (Webster, et al., 1998). In addition, links to numerous Web sites will be provided.

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CHAPTER 14

BARRIERS, GUIDELINES, AND RESEARCH NEEDS

Even though much has been learned in the mid-to-late 1990s regarding how to plan and conduct cumulative effects assessments (CEAs), there are still significant hindrances to the successful incorporation of CEA within the environmental impact assessment (EIA) process. Accordingly, this chapter summarizes some scientific and institutional barriers related to CEA. Suggestions for CEA guidelines are also included along with several research needs.

SCIENTIFIC AND INSTITUTIONAL BARRIERS TO CEA

Numerous scientific and institutional barriers have been identified in relation to the CEA process; and this section will identify a number of examples. First, such barriers include environmental and ecosystem complexity, difficulties in measuring individual effects, lack of attention to defining appropriate spatial and temporal boundaries, and lack of sustained interest in managing (or mitigating) cumulative effects. However, a systematic review of 12 case studies involving CEA has identified the following perspectives and actions as ways to minimize such barriers (Williamson, 1993): (1) emphasize scientific, cause-effect understanding and communication of the overall situation, each problem (cumulative effect), and problem interactions; (2) stress measurable overall action toward progressive goals for each problem; (3) use a generation-long, ecosystem-level, problem-solving, and solution-generating process; and (4) ratify an interagency collaborative drive toward cumulative improvement of the overall situation. Pragmatically, these perspectives and actions can be incorporated into an appropriate CEA process coupled with follow-on environmental management; the process should consist of the following steps (Williamson, 1994):

(1) in the scoping phase, define the ecological situation in specific terms of individual problem statements and select one strategy for each problem;

(2) in the analysis phase, investigate and document the problems and their causes in detail using the best available data and analytical tools and then set several goals;

(3) in the interpretation phase, develop and document options, estimate changes using mathematical models, and develop a plan; and

(4) in the direction phase, implement and incrementally improve the management plan and systematically evaluate, improve, and update the problem statements, data, analytical tools, and mathematical models.

For a specific type of ecological setting, Vestal, et al. (1995) noted the following scientific and institutional barriers to the conduction of CEA in coastal and/or marine environments: (1) significant gaps in scientific knowledge about cause and effect relationships; (2) absence of a single accepted approach for prediction of cumulative effects on coastal and/or marine ecosystems; (3) absence of unambiguous statutory requirements for doing CEA; (4) narrow court interpretations regarding

statutory and regulatory requirements; (5) inherent focus on individual sites (and projects) in decision-making; and (6) absence of a longer-term perspective for the environmental management of coastal and marine ecosystems. Obviously, these fundamental barriers cannot be resolved quickly. In fact, they are suggestive of the need for a long-term research program, particularly for numbers (1), (2), and (6).

A survey of substantive issues and needs related to CEA was recently conducted; the participants included 25 EIA practitioners in the United States (Cooper and Canter, 1997a). Five identified issues and possible approaches for addressing them are summarized in Table 14.1. The listed issues represent pragmatic concerns related to the planning and conduction of CEAs.

Sadar (1997) noted that institutional obstacles to effective CEA result from: (1) jurisdictional conflicts, confusions and turf battles over division of power, roles, and responsibilities of various levels of government; (2) lack of proper and effective cooperation among various agencies and departments of governments; (3) the absence of clear and precise division of responsibilities among the proponent(s) and governments regarding the implementation of remedial measures; and (4) the lack of accountability of governments regarding proper follow-up of results and recommendations contained in an impact study report. Further, jurisdictional barriers may inhibit the implementation of mitigation measures for project-level cumulative effects (Lawrence, 1997). In addition, CEA may be constrained by limitations in the jurisdictional authority of specific governmental agencies (Erickson, 1994). The obstacles are founded upon the lack of political will, on the part of key governmental decision makers, to embark upon a positive and aggressive program to incorporate CEA within the EIA process of their governmental agencies. If positive and aggressive stances were taken by EIA advocates and key decision makers within governmental agencies, most, if not all, of the above-listed institutional barriers could be minimized.

A key barrier is related to the fact that few pragmatic regulations or guidelines have been developed on how to plan and conduct a CEA (Kreske, 1996). In fact, this may be one of the most significant barriers to efficient and effective CEA studies. Because of the absence of specific guidance, cumulative effects may not be addressed at all, or they may be addressed too late in the EIA process. For example, McCold (1997) suggested that cumulative effects are not considered in a timely manner. If such effects are identified late in the process, there may be insufficient time to identify and characterize the impacts of other actions affecting the resources.

A second example related to consequences from the lack of guidelines is associated with two types of impact study documents generated in the EIA process in the United States. Preliminary studies are documented via environmental assessments (EAs), while more detailed studies lead to environmental impact statements (EISs). EISs are needed if the proposed action is anticipated to cause significant impacts on the biophysical and/or socioeconomic environments. The significance determination should include the consideration of direct, indirect, and cumulative effects. The first category of effects is typically addressed in an EA, with lesser attention to the latter two categories, particularly cumulative effects. For example, McCold and Holman (1995) reviewed 89 EAs that had been issued in 1992. Only 35 mentioned cumulative effects, with 13 concluding that there were either no cumulative effects, or no significant ones; however, no evidence or analysis was included to support such conclusions. Of the 22 EAs that documented the CEA, only three considered effects for all resources potentially affected by the action. Further, only two EAs identified other "past, present or reasonably foreseeable future" actions,

Table 14.1: Substantive CEA Issues Needing Improvement and Approaches for Addressing Them (after Cooper and Canter, 1997a)

Issue	Approaches for Issue
Types of Effects: Although additive effects were considered to be relatively easy to identify, synergistic and interactive effects are not well understood, and they are difficult to accurately predict. Identification of these latter two types of effects typically requires the use of complex and expensive models.	Recognition should be given to cumulative effects that can be identified as additive, synergistic, or interactive. An indication of the level of uncertainty associated with predicting such types of effects should be included in CEA documentation. Mass balance calculations for air and water pollutant emissions, resource usage, and/or resource losses are simple tools that can be used as a beginning step in addressing additive, synergistic, or interactive cumulative effects.
Defining Spatial Boundaries: It is important to define the geographic extent of a CEA study. Common deterrents to defining spatial boundaries include determining where cumulative effects end, the lack of funding and human resources to address the issue, procurement of data, and understanding environmental interactions and relationships.	Emphasis should be given to defining spatial boundaries for each identified environmental resource of concern, especially water-related resources, biological/ecological resources, and socio-economic resources. At a minimum relative to biological/ecological resources, ecoregion boundaries should be defined and the range of certain key species should be delineated. Geographic information systems (GISs) in combination with overlay mapping techniques are seen as excellent tools for delineating spatial boundaries. The capabilities of these techniques should be utilized if possible.
Defining Temporal Boundaries: It is necessary to consider past and future actions in the vicinity of the proposed action. However, common difficulties associated with establishing temporal boundaries include defining reasonably foreseeable actions, and predicting future events which may be influenced by political considerations.	Emphasis should be given to defining temporal boundaries for each pertinent environmental resource, especially in relation to water-related resources, biological/ecological resources, and socio-economic resources. As part of defining temporal boundaries, the design life of the proposed project, including the construction, operation, and post-operation stages, should be considered. Also, a "master plan projection" of the design life of all identified past, present, and foreseeable future actions in the study area should be developed. Contemplated actions as well as formally proposed actions should be considered as reasonably foreseeable future actions.
Availability and Use of Methods: Professional knowledge/judgment and other qualitative methods of predicting and assessing cumulative effects are the most utilized methodologies. Both professional knowledge/judgment and quantitative methods (i.e., models and indices) were considered to be potentially useful. However, the fact that quantitative methodologies were rated high in importance but are not widely used (compared to qualitative methods) could indicate that technical understanding and economic requirements for usage are limiting. Qualitative methodologies were identified as preferred tools due to their practicality.	Most EIA professionals wish to use quantitative or technical methods for predicting cumulative effects, but these methods are not always practical or feasible. Quantitative methodologies should be used as much as possible, especially simple models and indices. It is important to remember that quantitative techniques have many limitations (for example, natural systems are complex and their interactions not well known, and the availability of data is often limited) and they often produce inaccurate results. Simple questionnaire checklists are practical techniques that are excellent tools for identifying effects. Case studies (analogs) should also be utilized wherever possible. Finally, continued emphasis should be given to professional knowledge/judgment and common sense in the CEA process.
Monitoring of Experienced Cumulative Effects: This issues is important in establishing a knowledge base for prediction and assessment of cumulative effects. However, monitoring components are typically not included as follow-ons to CEA studies.	The establishment of monitoring programs is a first step in developing a sound CEA protocol that can produce objective and accurate information. Such monitoring should be a requirement of project proponents or be included in on-going monitoring efforts by governmental agencies. Accordingly, it is recommended that federal agencies set funds aside for the purpose of establishing special pilot monitoring programs. Each program should have a small and simple beginning, incorporating one or two projects to address specific issues. As data is generated, and their value becomes known, then the program could be expanded appropriately.

that, with the proposed action, could contribute to cumulative effects (McCold, 1997).

A second illustration of the lack of thorough consideration of cumulative effects in EAs is from a systematic review of 30 additional EAs prepared on a variety of project types in the United States. The review revealed that cumulative effects are neither normally mentioned nor thoroughly addressed (Burris and Canter, 1997a). Only 14 EAs noted the term, with the mentioned cumulative effects typically addressed in a qualitative manner without clear delineations of spatial and temporal boundaries and utilized guidelines or methodologies. If EAs are to be decision documents for determining if EISs need to be prepared, significance determinations for cumulative effects must be included. The resultant documentation could refer to the consideration of such effects and the determination that they are not significant; however, for some EAs cumulative effects may be the determining issue in decisions to prepare EISs.

GUIDELINES FOR CEA

To further illustrate the need for guidelines, the results from a recently completed study of the state-of-practice of CEA within the EIA process will be summarized (Burris and Canter, 1997c). The study included the review of selected EAs, EISs, and relevant court cases from the United States; the review of EIA regulations which incorporate CEA from 9 countries (or groups of countries); and the use of questionnaire survey completed by 57 EIA practitioners from the United States and internationally. The following observations and recommendations related to improving the practice of CEA could be used in formulating CEA guidelines (Burris and Canter, 1997c):

(1) standardization of a cumulative effects definition that incorporates the vital components of CEA, and that could easily be applied, is needed;

(2) regional planning/land development is an umbrella context that many countries use to incorporate CEA; however, the CEA should not get subsumed or become unrecognizable under this framework;

(3) in countries like the United States where structured land management/regional planning entities are typically not a part of the EIA process, for CEA to work, legislation supporting such a planning framework is needed; also, several constraints, such as regional planners not knowledgeable about CEA issues, and the lack of coordination between federal, regional, state, and local organizations, will need to be addressed;

(4) spatial and temporal boundaries are not always defined specifically; accordingly, emphasis needs to be given to the importance of defining when and where impacts will occur and the assumptions associated with these definitions;

(5) due to the number of court cases addressing "reasonably foreseeable future actions," special attention needs to be given to defining RFFAs and their relationship to associated study boundaries;

(6) monitoring of forecasted cumulative effects is a topic that needs more attention; although some impacts may take years to

accumulate or occur, "realistic" potential cumulative effects should be analyzed in the short-term, thereby providing guidance for future CEA studies; and

(7) more emphasis needs to be given to "regional planning environmental goals" relative to being able to convert generic CEA frameworks to "checklists" of specific items which need to be addressed in a given region in CEA studies.

Some criteria which can be used to determine if a CEA study has been properly conducted, and which could also serve as a basis for the development of CEA guidelines, were developed by the Cumulative Effects Assessment Working Group (1997). The following criteria are thus analogous to delineating an appropriate state-of-practice for CEA:

(1) The study area is large enough to allow the assessment of VECs that may be affected by the project. This may result in an area that is considerably larger than the project's "footprint." Each VEC may have a different study area.

(2) Other actions that have occurred, exist, or may yet occur which may also affect those same VECs are identified. Future actions that are approved within the study area must be considered; officially announced and reasonably foreseeable actions should be considered if they may affect those VECs and there is enough information about them to assess their effects. Some of these actions may be outside the study area if their influence extends for considerable distances and length of time.

(3) The incremental additive effects of the proposed project on the VECs are assessed. If the nature of the effect's interaction is more complex (e.g., synergistic), then assess the effect on that basis, or explain why that is not reasonable or possible.

(4) The total effect of the proposed project and other actions on the VECs are assessed.

(5) These total effects are compared to thresholds or policies, if available and the implications to the VECs are assessed.

(6) The analysis of these effects use quantitative techniques, if available, based on best available data. This should be enhanced by qualitative discussion based on best professional judgment.

(7) Mitigation, monitoring and effects management should be recommended (e.g., as part of an Environmental Protection Plan). These measures may be required at a regional scale (possibly with other stakeholders) to address broader concerns of effects on VECs.

(8) The significance of residual effects are clearly stated and defended.

It should be noted that recent governmental reports on CEA prepared in the United States (Council on Environmental Quality, 1997) and Canada (Cumulative Effects Assessment Working Group, 1997) could serve as the basis for developing guidelines. Information from these two reports has

been incorporated in many of the earlier chapters herein. Further, the U.S. Environmental Protection Agency has issued draft guidance on CEA for their reviewers of EISs and EAs (U.S. Environmental Protection Agency, 1998). This draft guidance, included herein as Appendix C, could be used even now to facilitate the planning and conduction of cumulative effects studies.

Documentation of the CEA process should be incorporated in any guidelines. For example, the results of a CEA can be placed in a separate chapter in an EIS, or they can be interwoven within the project environmental impacts chapter according to affected resources (Kreske, 1996). A list of topics for incorporation into a CEA report is in Table 14.2. These topics are relevant for the incorporation of CEA results within an environmental impact document, or as a separate appendix within such a document, or as a separate report. For a specific land area managed by a governmental agency, but with multiple actions over time, a separate "CEA document" that is updated periodically could be useful in fulfilling multiple requirements for EIA documents.

Documentation of the CEA within a resultant EIS is important for demonstrating the consideration of cumulative effects in the EIA process. Based on a systematic review of 33 EISs prepared in the United States (11 each from the U.S. Department of Agriculture: Forest Service, the U.S. Army Corps of Engineers, and the U.S. Department of Transportation: Federal Highway Administration) relative to 15 pre-defined criteria, it was determined that documentation consistency needs to be improved (Cooper and Canter, 1997b). This need exists due to lack of specific guidance on what should be addressed in such documentation. Accordingly, the following CEA documentation recommendations for an EIS have been promulgated (Cooper and Canter, 1997b):

(1) Cumulative effects should be defined at the beginning of the Environmental Consequences section (or chapter), along with definitions of direct impacts and indirect/secondary impacts. Further, cumulative effects should be reported in a separate sub-section in the Environmental Consequences section, and they should be addressed for each pertinent environmental resource and selected indicators. A summary of cumulative effects should also be included. Any cumulative effects considered insignificant should briefly be mentioned, and the rationale for their insignificance determination should be stated.

(2) Spatial and temporal boundaries for the CEA process should be defined specifically for each pertinent environmental resource. A map of spatial and temporal boundaries should be included and differentiated from the project boundaries. This should be included in the Environmental Consequences section.

(3) Guidelines and methodologies used in the CIA process should be specifically described in a structured step-by-step procedure. This could be addressed in an appendix to the EIS.

(4) Prior CEA studies (case studies) should be utilized, if available and pertinent to the project. All prior studies should be referenced. If no prior studies were utilized, then this should be documented. This could be included in either the Environmental Consequences section or in an appendix.

(5) An appendix should be included in the EIS for delineating the details of the CEA process.

Table 14.2: Suggested Topics for Inclusion in CEA Documentation (after Sadar, 1997)

•	Definition of cumulative effects.
•	Description of various forms of cumulative effects and the identification of those most likely to occur.
•	Identification of linkages among the bio-physical, socio-economic, human and ecosystem health effects and their relevance to human population and wildlife well being.
•	Description of selected impact prediction methodologies.
•	Description of the criteria used for determining the relative significance of valued ecosystem components and every cumulative effect.
•	Description of proposed mitigation and monitoring measures. Identification of the roles and responsibilities of various agencies, the proponent, and the public in implementing the proposed measures.
•	Identification of the agency/authority responsible for making the necessary adjustments in remedial measures and for taking required action based on the monitoring results.
•	Identification of study limitations such as inadequacy of available data/information, non-availability of proven methodologies for accurately predicting cumulative effects, and other limiting factors.

(6) Cumulative effects should be listed in the "Table of Contents" under the Environmental Consequences section. Further, a topical index should be incorporated into the EIS, and referrals to cumulative effects should be included. A glossary of terms may also be useful.

RESEARCH NEEDS

In summary based upon the review of principles, procedures, special issues, scoping, methods, mitigation, and monitoring in the earlier chapters, along with numerous case studies, the following observations and conclusions are drawn regarding research needs in CEA:

agency advocate

(1) Due to the importance of incorporating cumulative effects considerations in balanced decisions related to proposed projects, policies, plans, and/or programs, agency decision-makers should give priority emphasis to the development of necessary guidelines and scientific information to facilitate CEAs. The guidelines for a particular country should be in consonance with the EIA process; they should address "triggers" for CEA studies, and how to plan, conduct, and document such studies. Planning aspects include guidance on principles for establishing spatial and temporal boundaries, and information sources for the biophysical and socio-economic environments.

(2) CEA practice to date has focused on the biophysical, including ecological, aspects of the environment. Additional attention needs to be given to cumulative effects on the socio-economic environment, including the development of both identification and prediction methods.

(3) Fundamental research is needed on environmental pathways, and thresholds and carrying capacities for resources, ecosystems, and human communities. Of particular importance is the need for information on carrying capacity and limits of acceptable change.

(4) In order to conduct CEA, it is necessary for the study planners and implementers to adopt an holistic perspective relative to the environment. Such holistic perspectives might be limited in traditional academic backgrounds, thus suggesting the need for holistic type training for practitioners in EIA and CEA. Further, the planning and conduction of CEA studies can be scientifically as well as institutionally complicated. Accordingly, it is necessary for such study implementers to be creative in their consideration of methods and tools and to select those approaches which would be appropriate for the individual study requirements.

(5) There are numerous methods or tools which are available for addressing direct, indirect, and cumulative effects of projects and of strategic plans. One of the problems which appears to have developed in the context of cumulative effects studies is that a convenient deterrent for addressing such effects has been associated with indicating the absence of appropriate methods. While this certainly can be understood in some cases, it would not appear that this should be considered a generic deterrent for all such studies. However, specific research is still needed. For example, Clark (1993) noted that research on methods of assessment of cumulative

effects is needed, especially as it relates to ecosystem analysis. Also, a typology of methods is needed in relation to the identification and prediction of cumulative effects.

(6) An important issue for CEA is that of considering the cumulative effects from the perspective of affected resources, ecosystems, and human communities. This perspective is in contrast to the "proposed action" perspective used in the EIA process. Research may be needed to facilitate this shift in "mind set."

(7) Another topical issue in need of research is related to the institutional coordination and funding mechanisms for cumulative effects mitigation measures and appropriate monitoring. Further, the entire subject of appropriate management of cumulative effects needs to be conceptualized and adapted to the institutional frameworks within and between affected countries.

So that

(8) Because of the relative newness of CEA practice, there are considerable needs for information dissemination within and between agencies and countries, and among CEA practitioners. Further, specific training opportunities in CEA are needed, with such training planned around fundamental principles, steps, and methods coupled with illustrations from case studies.

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