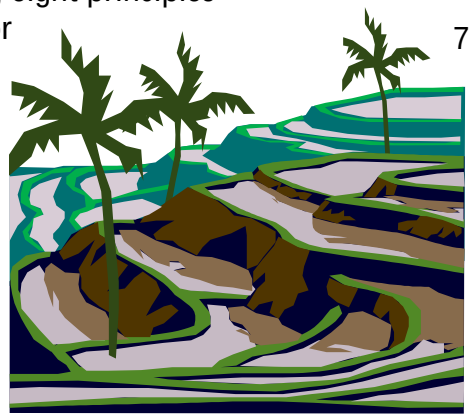
PRINCIPLES AND STEPS OF CEA

While there may be variations in definitions associated with cumulative effects (CEA), most efforts to incorporate CEA within the environmental impact assessment (EIA) process have focused on considering the proposed project or activity in relation to existing projects. Baseline conditions must be appropriately defined and the combined effects from the proposed action and existing projects on environmental media, natural resources, and socio-economic systems addressed.

In the United States, eight principles have been delineated for CEAs. The principles were derived from the definition of 'cumulative impacts' in the Council on Environmental Quality (CEQ) regulations, from surveys of EIA practitioners, and from a review of published literature. These principles can be summarized as follows:



1. Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions (RFFA)
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 has taken the actions
3. Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and human community affected
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
5. Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries
6. Cumulative effects may result from the accumulation of similar effects or the synergistic interaction of different effects
7. Cumulative effects may last for many years beyond the life of the action that caused the effects
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.

The CEQ principles are considered sufficiently generic that they can be applied in the worldwide practice of CEA. They can also be further distilled into eleven pragmatic steps organized in accordance with three components of the basic EIA process as summarized in Table 1. These steps, while focused on CEA, are conceptually similar to traditional steps used within the EIA process.

Table 1 Steps in CEA to be addressed during the EIA process

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 during 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 the management strategy

Special Issues in CEA

The EIA process has typically focused on a project or activity (i.e., the proposed action) and its resultant consequences (i.e., effects or impacts) for biophysical and socioeconomic environments. CEA focuses more broadly on affected environmental components or valued environmental or ecosystem components (VEC) and the 'contributions' of multiple projects toward their resultant stress. Further, planning a CEA study involves delineating appropriate spatial and temporal boundaries, identifying RFFA in the environs of a proposed action, and determining the significance of predicted cumulative effects. These issues are considered in the following sections.

Delineating Spatial and Temporal Boundaries

Appropriate spatial and temporal boundaries for a CEA should be based on both 'activity information' and 'environmental information'. 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 be appropriate for different types of cumulative effects.

Some 'rules of thumb' related to establishing spatial boundaries for a CEA study are summarized in Table 2 Even though these rules are straightforward, difficulties can arise in defining such boundaries. Examples include:

- Lack of pertinent information
- Need for different boundaries for different effects/resource areas
- Drawing the line on where effects stop
- Incomplete understanding of linkages that may expand or confine the area affected
- Lack of funds and time to address incomplete knowledge
- Determining a balance between environmental components, boundaries, and institutional jurisdictions.

Delineating temporal boundaries involves determining how far in the past to consider establishing the historical boundary, and how far in the future to go in designating the time period encompassing RFFA. Unfortunately, no precise guidelines exist for these considerations. Specific temporal boundaries will be dependent on the type of project or activity, its location, and historical and planned actions in the vicinity. Examples of pragmatic questions, issues and information to consider in establishing temporal boundaries are provided in Table 3.

Table 2 Rules of thumb for consideration in establishing spatial boundaries

1. Establish a local study area to separate out the obvious, easily understood effects, which can be mitigated.
2. Establish a regional study area that includes possible interactions with other actions. Consider the interests of other stakeholders.
3. Use of several boundaries (e.g., one for each environmental component) is often preferable to a single boundary.
4. Boundaries should expand sufficiently to address the cause-effect relationships between actions and VECs.
5. Characterize the abundance and distribution of VECs at a local, regional, or larger scales if necessary (e.g., for very rare species), and ensure that the boundaries take this into account.
6. Determine if geographic constraints may limit cumulative effects within a relatively confined area near the action.
7. 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).
8. 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.
9. Estimate the reversibility of the effects (i.e., time required for recovery).
10. Be prepared to adjust the boundaries during the assessment process if new information suggests that this is warranted, and defend any such changes.

Table 3 Questions and issues for consideration in establishing temporal boundaries

1. Does the project proponent have a written policy regarding temporal boundary delineations? In the absence of a written policy, what has been the practice of the proponent in establishing temporal boundaries for other projects?

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

3. 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?

4. Do any regional development or general environmental management plans exist and 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?

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

6. 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?

7. 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?

8. 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 a given time period due to changes in manufacturing technologies? Will the capacity of a waste disposal site be used up in a certain number of years, and are there longer term land reclamation efforts which will be implemented?

9. If cumulative effects are associated with land use changes and/or the emissions of air and/or water pollutants, are historical data available? Can information of this type be procured for future years?

10. 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? Examples include the half-life (i.e., environmental biodegradability) of pollutants, and long-term transport concerns for the sub-surface environment.

To summarize, difficulties which can arise in delineating temporal and spatial boundaries include:

- Defining where 'short term' ends and 'long term' begins
- Determining what constitutes RFFA
- Correlating old and current data (e.g., past data may be nonexistent, scarce, incomplete, or inaccurate)
- Possible absence of fundamental scientific and historical data
- Determining a proper balance between the short-term interests (e.g., 10-20 years) of planning authorities and long-term sustainability interests
- Recognizing that appropriate spatial boundaries may shift over time
- Insufficient time and funding for the CEA
- Uncertainty and lack of confidence in predictions.

Determining Reasonably Foreseeable Future Actions

Consideration of cumulative effects within the EIA process should involve an analysis of the proposed action in view of past, present, and RFFA. One challenge is the determination of what activities should be considered as RFFA For over two decades, the answer to the question "When does a contemplated action become 'reasonably foreseeable?" has been argued in the USA court system. At least 40 legal cases have involved cumulative effects, and many of them hinged on the determination of RFFA. Based on a review of these court cases and the issues addressed, future activities could be evaluated with respect to the eight steps listed in Table 4. Following these steps will help ensure that most, if not all, relevant RFFA are included. Further, it will demonstrate to decision makers and regulators, and the public, that a concerted effort was made to comply with the spirit of EIA regulations and provide the pertinent information needed to make responsible decisions with respect to the protection of the environment.

While the basis for the eight-step CEQ procedure detailed here is a review of US court cases, it is not intended that its application be restricted to CEA studies in North America. The spirit and intent of the US National Environmental Protection Act is similar to that of environmental provisions of other countries in that all intend to provide decision makers with more complete and relevant information as to the environmental impacts of their actions.

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 other unique considerations. A sequenced approach for cumulative impacts determination, based upon a review of significance definitions in the EIA laws, regulations and/or guidelines of numerous countries, is provided in Table 5.

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. A threshold value can be either a maximum or minimum number (i.e., a criteria or a standard), or a related qualitative measure, which, if exceeded

Table 4 Steps in determining reasonably foreseeable future actions

Step 1	Determine reasonable temporal and spatial boundaries with respect to the availability of information, the realm of influence or control exerted by the responsible government agency, and the nature of the environmental impacts of the original project.
Step 2	Within those boundaries, if additional formal proposals are pending approval, include them as RFFA.
Step 3	Conduct forecasting to determine possible, plausible, conceivable, and probable future activities both internal and external that fall within the temporal and spatial boundaries established in Step 1.
Step 4	Evaluate the list from Step 3 to determine a possible connection 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 RFFA.
Step 5	Again evaluating the list of proposals from Step 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 RFFA.
Step 6	Within the area of concern, determine the existence of any planning documents 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 RFFA.
Step 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 RFFA are determined to be 'insignificant' or impossible to evaluate at this time, exclude them from the list. The remaining RFFA should be included in the CEA.
Step 8	Document the evaluation of RFFA and include that documentation in the final environmental impact study report.

or not met, causes the predicted effect. Thresholds are related to the carrying capacity of the relevant biophysical or socio-economic systems.

Carrying capacity can be defined as the ability of biophysical or socio-economic 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. Often, the problem of applying the concepts of cumulative effects and thresholds to ecological systems lies in the difficulty of understanding the complex interactions between the components of such ecosystems.

Finally, societies need to determine the limits of acceptable change in environmental components resulting from natural resource extraction and development. This concept can be useful in dealing with socio-economic components and in incorporating sustainable development considerations into CEA.

Table 5 Sequenced approach to significance determination in CEA

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 and regulations?
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 and regulations?
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?
9. 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 non-renewable resources)?
10. Are there differences in the development and environmental protection/conservation policies of governmental agencies both within and between potentially affected countries? This may be a significant concern when addressing trans-boundary cumulative effects.